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A COMPARATIVE STUDY OF THE BRONCHO-PULMONARY
SEGMENTS AND PULMONARY BLOOD VESSELS WITH
SPECIAL REFERENCE TO THE DOG

Mohammed Ishaq
M.B., B.S. (Punjab)

Thesis presented for the Degree
of Doctor of Philosophy,
University of Edinburgh.
November, 1953.



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ACKNOWLEDGEMENTS

The writer wishes to thank Professor J.C. Brash and Professor T. Grahame for their inspiring guidance and encouragement, and also for their kindness in providing facilities in their respective departments.

To the members of the staff of the Anatomy Departments of the University of Edinburgh and the Royal (Dick) Veterinary School the writer is indebted for their helpful and willing co-operation.

Special thanks are due to Dr. E.C. Appleby and the staff members of the Pathology Department of the Royal (Dick) Veterinary School for providing material for this study.

To Mr. Richard Hood of the same School the writer is grateful for the photography.

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SECTION I

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INTRODUCTION

Scope of work

Aeby, an anatomist, in 1880, published his book, a pioneer work, "Der Bronchialbaum der Säugetiere und des Menschen", based on an extensive comparative study.

In 1889 Ewart, a physician, in his monograph, "The Bronchi and Pulmonary Blood Vessels", gave a detailed topographical account of the bronchi and blood vessels of the human lung on the basis of which he criticised Aeby's views. This was the beginning of certain controversies which have existed to the present day. These controversies have since then centred mainly around the mode of branching of the bronchial tree, the presence of the "stem-bronchus" of Aeby and the homologies between the right and the left lung.

The approaches of these two pioneer workers were entirely from different angles and from the opposite ends of the mammalian series. Although Ewart's work is characterised by great detail, his field of work was narrow and his point of view clinical, as compared to Aeby's much wider comparative approach.

It is not the aim of this study to solve these controversies, but in view of the recent accumulation of literature on human lung a fresh approach from the comparative angle may provide grounds for reconciliation of some of the existing conflicts.

Little work has been done on the lungs of mammals other than those of man, on lines on which recent progress has been made. Dog as the chief animal in this study has been selected for the following reasons:-

- (1) It is an important domestic animal and therefore of special

interest to the veterinary clinician. For any further advancement in the clinical fields of veterinary science a knowledge of intrapulmonary bronchial and vascular anatomy would be indispensable.

(2) Since 1881, when Gluck performed the first experimental pneumonectomy, the dog has played an important role in the progress towards the development of modern thoracic surgery. A review of the surveys of the literature on experimental work such as given by Adams and Livingstone (1932), Heuer (1934) and Crafoord (1938), does not indicate the existence of any knowledge of the intrapulmonary anatomy of any of the experimental animals. Further progress can be anticipated with such a knowledge at hand.

(3) The convenient size of the dog's lungs and the ease with which they can be secured may be considered a secondary reason.

The chief aim of this study is to make a comparison of bronchopulmonary segments and blood vessels of the lungs of dog and man. Such a comparison may throw light on the significance of some of the variations so far observed in the bronchi and vessels of the human lung.

Hitherto, the concept of bronchopulmonary segment, on account of its clinical utility, has remained restricted to the human lung and this has been the sole point of view of all the recent investigators. To the best of the writer's knowledge no serious attempts have been made to review the bronchopulmonary segment in the light of comparative anatomy. The only workers who have touched upon this aspect of the problem are Neil and coworkers of New Zealand. Their observations are incorporated in the discussion at the end of the thesis.

At the time of undertaking this work little or no work on the morphology of the bronchi and the vessels of the lungs of the dog

was available. It was therefore considered necessary to make a complete survey of these organs first. A separate section of the thesis is devoted to the results of this survey.

When the present work was nearing completion, the writer encountered an Italian article published by Tonelli (1951) on the bronchopulmonary segments of the dog. His results differ fundamentally on certain points from the results of the present study. He does not deal with the blood vessels. A review of his work is incorporated in the discussion.

The lungs of a few other animals, when available, were studied, and this work is included in the thesis in a separate section.

The bronchial vessels, which are of much theoretical interest, have been excluded in this study on account of the lack of time and the difficulties involved in their demonstration by dissection and injections.

In view of the nature of the material no distinction has been made of the sex or the breeds of the dogs. This is also unnecessary because no such data are available in the case of the human lung.

Note on Illustrations

The wide range of variations in the broncho-vascular patterns of the lungs has not permitted the illustration of every variation. Most of the typical features, however, have been illustrated by photographs and drawings. Throughout the text reference has been made to the actual specimens which have been deposited in the Anatomy Department of the University of Edinburgh.

In some of the drawings veins have been shown as red and arteries blue to indicate the physiological colours of the blood they convey.

All drawings are original and made by the writer himself.

SURVEY OF LITERATURE

The literature on the anatomy of lung has been contributed by anatomists, clinicians, surgeons, bronchologists and radiologists. It is so vast that a complete review of all the works so far published would be outside the scope of this work. The following survey will be confined to those important contributions which have substantially influenced the course of anatomical research on the lung, and thereby contributed to our modern knowledge.

The most important landmark is the publication, in 1880, of Aeby's monograph. It marks the beginning of a systematic research on macroscopic pulmonary anatomy so much so that the whole period of the history of lung may be divided into two main periods - a pre-Aeby and a post-Aeby period.

The historical accounts given by Ewart (1889), Young (1940), Miller (1950) and Cole (in "The History of Anatomical Injections" in Singer's "Studies in the History and Method of Science", 1917-21), and a reference to Quain's Elements of Anatomy (1876, 8th Ed.) show that in the pre-Aeby period the anatomical knowledge of the lung was confined to gross external anatomy only. Interest was restricted then to micro-anatomy and physiology. The lobule was the "ultimate anatomical unit" (Ewart).

With regard to the mode of branching of bronchi, the theory of dichotomy was generally accepted, and the bronchial tree was considered symmetrical on both sides.

Aeby, on the basis of his extensive comparative work, described a common mammalian bronchial plan, and forwarded his

three main theories: (1) the existence of an eparterial and a hyparterial system of bronchi, (2) a monopodic mode of division, and (3) the existence of a "stem bronchus". Nine years later, in 1889, Ewart published his classical work on the human lung. He criticised these three theories of Aeby in the light of his findings in the human lung, and also gave a most detailed topographical account of bronchi and pulmonary blood vessels. At that time a study of the anatomy of bronchi and pulmonary blood vessels had little practical value. It is not surprising, therefore, that the part of his monograph dealing with the topography received scant attention, but his theoretical criticism of Aeby's views on the bronchial tree of mammalia aroused an intense interest. It caused certain controversies which acted as a stimulus for further morphological and embryological studies.

The next three decades comprise a period devoted to the controversies arising out of Aeby-Ewart "conflicts". Aeby's "reduction" theory, Willach's "migration" theory (supported by Narath, 1901, and earlier held by Huntington, 1898) came to an end when Huntington propounded his "selection theory" in 1920, which has not been refuted since then. (These theories will be discussed later.) During this period appeared some important contributions such as Huntington's article on the eparterial system of mammalia, published in 1898; Narath's monumental work, published in 1901, on the same subject as that of Aeby's work; and Flint's embryological studies on the lungs of pig in 1906. Huntington's masterly dissertation on the theories of evolution of mammalian lung and the propounding of his "selection" theory, in 1920, may be said to close the

first chapter of the history of lung which began with the work of Aeby.

The second chapter may be said to commence when interest was renewed in 1932, a year in which Kramer and Glass defined the "broncho-pulmonary segment". Since then research has revolved round the broncho-pulmonary segments of human lung.

In the following pages the work of Aeby, Ewart, Narath, Flint and Huntington will first be reviewed, and will then be followed by a review of recent literature.

by their division into lobar bronchi, a view held prior to Aeby's work. According to him, "There exists nothing like a dichotomous division of the two tracheal branches" and each branch of the trachea "preserves its full independence" as a "basic axial structure" ("Grundlegendes Achsengebilde"), the "Stammbronchus".

From the hilus onwards the stem bronchus "sends out numerous side branches" at acute angles. "The bronchial tree is not polypodic but strictly monopodic contrary to the falsely assumed dichotomous mode of branching." This is true also for the further division of the side branches. Variations from this strict rule are generally found only in outlying areas.

Aeby attached much importance to the points at which the pulmonary arteries cross the stem bronchi. These points, according to him, are constant, and have been used by him to divide the bronchial tree into two systems, the "aparterial" and the "hyparterial". Few "side-bronchi", according to him, belong to the aptarterial, the majority to the hyparterial area.

AEBY'S WORK

Aeby, as stated before, published his pioneer work in 1880. He confined his study to the "primary" branches of the two main bronchi. He studied the bronchi of 50 species of mammals belonging to 14 different families.

He described a common basic plan of bronchi for all mammals, which according to him can be traced "everywhere inspite of multiple modifications".

He denied the termination of the right and the left bronchi by their division into lobar bronchi, a view held prior to Aeby's work. According to him, "There exists nothing like a dichotomous division of the two tracheal branches" and each branch of the trachea "preserves its full independence" as a "basic axial structure" ("grundlegendes Achsengebilde"), the "Stammbronchus".

From the hilus onwards the stem bronchus "sends out numerous side branches" at acute angles. "The bronchial tree is not polypodic but strictly monopodic contrary to the falsely assumed dichotomous mode of branching. This is true also for the further division of the side branches. Variations from this strict rule are generally found only in outlying areas."

Aeby attached much importance to the points at which the pulmonary arteries cross the stem bronchi. These points, according to him, are constant, and have been used by him to divide the bronchial tree into two systems, the "eparterial" and the "hyparterial". Few "side-bronchi", according to him, belong to the eparterial, the majority belonging to the hyparterial area.

The "hyparterial system" of the right and left sides are, apart from "disturbances" of a "subordinate nature" always symmetrical. It comprises four short dorsal (d_1 , d_2 , d_3 and d_4) and four long ventral (V_1 , V_2 , V_3 and V_4) branches which are usually placed alternately, the latter obtaining a higher position on the stem.

Between the origins of ventral and dorsal branches are attached the accessory bronchi ("Nebenbronchien") which originate by a process of "migration" ("Uebertragung") from the dorsal and ventral bronchi. They are irregular and of a "secondary importance". The largest and the most constant among them is the "cardiac" bronchus originating from the right bronchus. This, he considers, is derived from bronchus V_1 as a "coordinate" bronchus. It is important because in many mammals it supplies a separate lobe. It may be present on the left side or may be entirely absent.

The "eparterial system" is generally asymmetrical. It may be present on one or on both sides. When present on one side, it is always on the right side. The origin of its bronchus may be bronchial or tracheal. It arises between the dorsal and the ventral bronchi.

Depending upon the existence or absence of the eparterial bronchus on one or both sides and on its site of origin, Aebly classified the lungs into the following types:-

- I. Bronchial tree with eparterial bronchus on both sides.
 - a) eparterial bronchus bronchial on both sides.
 - b) eparterial bronchus bronchial on left and tracheal on right side.
- II. Bronchial tree with eparterial bronchus only on right side.
 - a) eparterial bronchus bronchial.

b) eparterial bronchus tracheal.

III. Bronchial tree without eparterial bronchus.

He concluded that the primitive mammalian bronchial tree was the bilaterally symmetrical type I, with eparterial bronchus on both sides, and the other two types were derived from it by a process of reduction. This theory was later called the "reduction theory" by Huntington (1920). The majority of the existing mammals belong to the bronchial tree type II with eparterial bronchus on the right side.

However, Aeby refers to some mammals such as the horse and the tapir among perissodactyles, the lama among artiodactyles and the porcupine among rodents, which possess bronchial trees different from the types possessed by other members of their respective families and points to the need for further research.

The "reduction theory" of Aeby/^{was} supported by D'Hardiviller (1896 and 1897) and Bremer (1904), quoted by Huntington (1920). D'Hardiviller claimed that in rabbit embryos of 13 days and 6 hours a left eparterial bronchus always appeared as a "hollow epithelial vesicle" and then during subsequent development it gradually disappears.

Aeby himself, in support of his theory of monopody, refers to Küttner who, through his embryological studies, had previously stressed that the growth takes place monopodically at the summit of the growing epithelium, and the lateral branches arise at right angles, later reduced to acute angles.

Regarding homology, Aeby considered the right middle lobe and the left upper lobe in man, each supplied by bronchus V_1 , as homologous. The right upper lobe, supplied by the eparterial bronchus, had, according to him, no counterpart on the left side.

As regards blood vessels, Aeby observed that the arterial tree is a simple repetition of the bronchial tree. In the arterial tree too he found no dichotomy but a steady "monopodic evolution". The veins, however, according to him, allow themselves "greater freedom" and their stems lie in "front" of bronchi, whereas the arteries lie on the dorsal aspects.

This, in brief outline, is the summary of Aeby's work.

EWART'S WORK

Ewart published his work in 1889. Whereas Aeby's work was a comparative morphological study, covering a much wider field, Ewart confined his study to the human lungs only. His is the first detailed account of the human lung.

He, as a physician and a pathologist, was the first to visualise the necessity of the knowledge of anatomy of the lung and to point out that the deficiency of this knowledge was the cause of "the halting and spasmodic feature in the development of pulmonary surgery".

He was also the first to realise the necessity of a proper nomenclature, and suggested one, which, in contrast to Aeby's system of notation, is based on topographical relationships to the adjoining areas.

He gave a detailed topographical account of the bronchi and pulmonary blood vessels. He extended his research beyond the "primary" branches of Aeby.

His work is often criticised as full of unnecessary details, but such a criticism appears to be the result of failing to appreciate the fact that, at a time when the usefulness of

such a study was merely anticipated, there was nothing to guide him to limit the extent of his work. Moreover, one of the chief aims of his study, as the title of his book indicates, was a criticism of Aeby's three main theories, the existence of the stem bronchus, the monopodic mode of division and the eparterial and hyparterial systems of bronchi. Without a detailed study, such a criticism would have been impossible. Ewart himself refers to the excessive details in his work as "apparently devoid of practical interest" but he approached the task in a "spirit of completeness". Again Ewart remarks in his preface about his own work that ".... in itself the work, although exclusively devoted to anatomical facts, cannot claim to be practical in the strict sense of the word. It may nevertheless indicate the path which will lead to practical results. Clinical utility was its original motive, and if it should at least succeed in stimulating a search for the practical application of an improved knowledge of the bronchi and of the pulmonary blood vessels, neither the motive nor the performance will need further justification."

To-day these words stand undoubtedly true.

Ewart refuted each of the three theories of Aeby. He held that the mode of division of bronchi was dichotomous, and that the bronchi in the human lung have a radiating arrangement fanning out from the pulmonary roots. According to him, dichotomy, understood by Aeby as "even" dichotomy, was impossible in the lung. Due to the shape of the thorax, the anatomical circumstances and the "law of adaptation", unevenness is more likely. In his opinion, "tripodic division" exists only in appearance.

The stem bronchus, according to him, cannot be identified in the lower part of the human lung. He concluded that the bronchial stem was the result of anatomical and physiological necessities and adaptation, and that its appearance was not the result of an abstract law. He, however, conceded the use of the term "bronchial stem" in respect of its "convenience" only.

Further, Ewart questioned the justification of using the position of the pulmonary artery as a test for dividing the bronchial tree into Aeby's eparterial and hyparterial systems.

Most important of all his contributions, perhaps, was the definition of the "separate respiratory districts", which later were recognised as the broncho-pulmonary segments.

Ewart's work, however, due to the excessive details, relatively few illustrations, often impossible to read, and a most complicated system of his nomenclature, attracted little attention as far as his anatomical facts were concerned. Aeby's account remained the standard account in the text-books up till very recently.

NARATH'S WORK

Twelve years after the publication of Ewart's monograph, Narath produced, in 1901, a monumental treatise with the same title as that of Aeby's work. He examined a total of 435 pairs of lungs, by dissections and by making casts, belonging to 133 species and 18 orders of mammals.

Narath confirmed Aeby's views on the stem bronchus and agreed that in the human lung the stem bronchus does not stand out so clearly as in other mammals on account of well developed side branches.

He disagreed with Aeby that the relationship of the pulmonary artery with the stem bronchus was constant, and, like Ewart, gave no importance to the point at which they cross. He, therefore, saw no fundamental difference between the eparterial and the hyparterial bronchi.

Further, he disagreed with the reduction theory of Aeby. He supported the "migration" theory originally formulated by Willach (1888), also supported by many others - Young and Robinson (1889), Huntington (1898), Narath (1892), and Blisnianskaja (1904) - quoted by Huntington (1920).

According to this theory, all dorsal bronchi are derived from the ventral branches by a process of splitting and migration. The eparterial bronchus is derived from the first ventral bronchus and it shifts higher up on the stem.

Similarly, the cardiac bronchus, according to Narath, is derived from the second ventral bronchus (V_2) and not the first ventral as Aeby thought. He stated that a side branch of V_2 in the left lung should be considered homologous to it.

It may be pointed out that the concept of migration, usually attributed to Willach, is not different from the "Uebertragung" of Aeby, by which the latter derives his "Nebenbronchien", the "cardiac" bronchus being one of them except that it is the most constant accessory bronchus.

According to Narath, contrary to Aeby's view, the primitive ancestral bronchial pattern conformed to Type III of Aeby, i.e., with no eparterial bronchus on either side. In most of the mammals extension and migration of one of the side branches of the first ventral bronchi has occurred on one side, and in some the extension of the evolutionary process has

resulted in a bilateral eparterial bronchus.

FLINT'S WORK

Flint published his researches on the development of the lungs of pig in 1906.

He refuted the reduction and the migration theories on the basis of his embryological studies, because he neither found the development of an eparterial bronchus (his Lateral 1) on the left side at any time in the life history of the pig, nor did he find any relation between the ventral bronchi (his Lateral series) and the dorsal bronchi.

He recognised four series of bronchi, "dorsal", "lateral" (Aeby's ventral), "ventral" and "medial" (the latter two corresponding to Aeby's accessory bronchi). According to him, all are "independent productions" of the stem and are not accessory in the sense of Aeby.

He concluded: "The growth of the main series of bronchi is monopodial in character, that is to say, they are produced without a definite division of the end bud. New elements are not always produced from the end bud, but may be formed from the stem some distance from its terminus."

"Subsequent division of the branches may occur either by monopody or dichotomy. Often monopodial production of buds persists for one or two generations on the main bronchi, then the method becomes dichotomous either equal or unequal in nature, depending somewhat on the space in which the bronchi have to divide. In the case of equal division of the bud, however, one fork grows on to become the stem while the other remains as the side branch."

According to him, the monopodial growth of the mammalian stem bronchus and its principal branches shows the phylogenetic relationship to the lungs of the lower animals which are products of the monopodial growth. The mammalian stem recapitulates ontogenetically the growth process of the simple lung before producing dichotomously the peripheral respiratory structures which are used in mammalian respiration, and the stem bronchus and its chief branches correspond to the simple lungs.

He explained the asymmetry of the two lungs as a result of suppression of the "Lateral 1" (eparterial bronchus) and the "Ventral 2" (the cardiac bronchus of Aeby) on the left side, due to descent of the aortic arch and the ductus arteriosum, and the "vena pulmonalis".

He further stressed the influence of space on the growth of bronchi. He calls the ventral bronchi of Aeby as Lateral branches to which the eparterial bronchus (L_1) bears a "serial relationship". They have an appearance of ventral bronchi because they are "compelled to grow in the space between the ribs and the liver and consequently follow the curvature of the chest wall".

He also stated that "When, a bronchus is suppressed, an adjacent branch will grow into the area usually supplied by the missing element, substituting for its loss"

According to him, "bronchi never wander. They remain firmly fixed on the stem or the side branches where they originate. Not uncommonly their directions may be altered, however, by changes in the space in which they develop."

He suggests that, "the difference in the branching of

the stem in the Lobus inferior of the human lung when compared with the pig may be sought in its altered topography owing to the erect posture which changes principally the position of the liver."

Flint also described the development of the pulmonary blood vessels in the lungs.

HUNTINGTON'S WORK

Huntington pointed out the incorrectness of the assumption of earlier workers that the reptilian lung possessed a bilateral eparterial system. In his dissertation on the theories of pulmonary evolution in mammalia, based mostly on his own work, he supported Flint by arguing against the reduction theory and the migration theories, and propounded the new "Selection theory" of his own.

According to this theory, the increase of the respiratory area, during the process of evolution, from the amphibian and reptilian lung to the mammalian lung, is due to increased demands of oxygenation. Further, it is the result of adaptation to the thoracic structures, the space disposition, the mode of locomotion and the general environment.

According to him, the increase in the respiratory area has found "its morphological expression in the neomorph development of the cranio-ventral pulmonary districts", which, according to him, are extensively developed in ungulates which have a high degree of tissue combustion of a fairly constant rate, and in aquatic adaptations, such as cetaceans, which possess "a very rapid intermittent metabolism called for at definite periods with intervals during which respiration is

suspended".

This "neomorph development" is supplied by the "ascending branch of the first ventral bronchus". As this new area enlarges, a cleft appears which divides the entire organ into a cranial segment (the primitive upper lobe) and a caudal segment (the remaining lung). "The points of origin of V_1 , supplying the ventral portion, and its ascending branch..... distributed to the cranial segment of the upper lobe, are too closely approximated on the bronchial tree to admit of much additional peripheral unfolding of their terminal branches." From a more favourable site on the right bronchus a new bronchial bud develops to meet the demand, and supplies the area of the independent upper lobe which can expand further. This new element is the eparterial bronchus, which lies "behind rather than above the main right pulmonary artery".

"On the left side conditions remain much as they were before the inauguration of the right eparterial development." Ninety per cent of the living forms conform to this dominant type, conforming to Aeby's type II a, with the eparterial bronchus derived only from the right stem bronchus.

Extension of the same evolutionary process to the left lung results in the symmetrical bilateral eparterial tree of bronchial derivation (Aeby's type I), and if a point on the tracheal epithelium is selected for proliferation of the right eparterial component the typical arteriodactyle and cetacean lung results (Aeby's type II b), and if, in addition, the left stem bronchus develops an eparterial bronchus the lung conforms to Aeby's type I b (Camelidae and Giraffa).

Thus Huntington also, like Ewart and Narath, rejected the "eparterial" and "hyarterial" systems of bronchi along with the reduction and migration theories. His arguments also do away with the common mammalian basic plan of bronchi described by Aeby. He also objects to the "splitting" and "wandering" of bronchi. These conclusions of his have never been questioned.

However, here, it is interesting to note that earlier Ewart did not fail to remark that "branches..... arise as necessity requires, on the outer and on the inner side of bronchial stem". Only, Ewart did not elaborate this view.

Recent Literature

A new era may be said to begin with the publication of the paper by Kramer and Glass in 1932. Realising the need for "greater accuracy in localisation" of the lung abscess in "smaller and more accurate unit than the lobe", they divided each human lung into eleven areas which they termed bronchopulmonary segments. These correspond almost exactly to Ewart's nine "districts" of each lung, except that Kramer and Glass split the "pectoral" and the "cardiac" distributions of Ewart (the anterior segment of right upper lobe, and the middle lobe of the right lung respectively) into two segments each.

Kramer and Glass stressed the importance of a knowledge of the arrangement of the segmental orifices, and of the size, shape and position ^{of the segments} in the lung. In their 80 specimens,

they found no variations in 85%; the remaining 15% have not been described.

In the same year, Nelson published a different scheme of divisions of the human lung, according to which he divided each lung into the following four areas:-

(1) The "upper" (the right upper lobe; the upper division of the left upper lobe).

(2) The "ventral" (the right middle lobe; the lower division of the left upper lobe).

(3) The "dorsal" (the apical segment of the lower lobe of each lung).

(4) The "lower" (the remaining lower lobe of each lung).

Each of these four areas was given by him the status of a lobe. He stressed the independent nature of the "dorsal lobe".

Two years later, in 1934, Nelson published a brief account of the bronchi in relation to postural drainage, and further subdivided the "upper" and the "lower lobes" into a number of segments (see Nelson, Table 1), leaving the "dorsal" and the "ventral lobes" undivided.

Nelson, however, gave no importance to the cardiac bronchus, (the medial basal segmental bronchus) - "on account of its small size".

In 1934, Glass discussed the roentgenographic aspects of broncho-pulmonary segments.

Kramer and Glass, and Nelson may be called the pioneers who revived interest in the anatomy of human lung, which had remained ignored since the publication of Ewart's account. The credit of the establishment of broncho-pulmonary segment

goes to Kramer and Glass, but one must not forget that Ewart had already described the nine "districts" or "distributions".

These important papers of Kramer and Glass, and Nelson were followed by the publication of different accounts of bronchi and broncho-pulmonary segments, such as those of Lucien and Weber (1936), Herrnheiser (1936, quoted by Huizinga and Smelt, 1949), Neil and co-workers (1937, 1939, 1946, July 1949, August 1949, 1950), Behr and Huizinga (1938), Huizinga and Behr (1940), Pothoven and Huizinga (1943), Peirce and Stocking (1939), Churchill and Belsey (1939), Adams and Davenport (1942), Foster-Carter (1942, 1943a, 1943b, 1946), Foster-Carter and Hoyle (1945), Brock (1942, 1943, 1944), and Jackson and Huber (1943).

Most of these authors suggested terminologies which differed from the one originally suggested by Kramer and Glass, and so did the segmental patterns described by them.

Levitin and Brunn (1936) made a radiological study of the lower lobes and supported Nelson in dividing them into superior and inferior divisions on embryological, anatomical, pathological and radiological basis.

Adams and Davenport (1942) proposed the term "division" to indicate "surgically and pathologically important anatomic portions of lobes". According to them, the left upper lobe has an "apical" and a "lingular" division, and each lower lobe has a "dorsal" and a "basal" division; the right upper lobe represents the "apical division"; the right middle lobe "possesses no divisional substance". They refer to the broncho-pulmonary segments as "subdivisions". It will be noticed that this concept is not different from that of

Nelson, except for the introduction of the terms "divisions" and "subdivisions". According to them, these

Churchill and Belsey (1939) described the anatomy of the lingula, its bronchus and blood vessels, and also of the apical segment of the lower lobe. They were the first to apply the principles of segmental pneumonectomy in lingula.

Churchill (1940) was responsible for giving prominence to the broncho-pulmonary segments as surgical units.

Between 1936 and 1950, Neil and co-workers published no less than ten papers on the anatomy of the bronchial tree. Only six out of these (Neil et al, 1938, 1939; Neil and Gilmour, 1946, 1949, 1949; Neil, 1950) were available for study. In these articles they have described and discussed the broncho-pulmonary anatomy and their nomenclature. They are the only authors who have touched upon the comparative aspects of the broncho-pulmonary segments briefly. Their findings will be incorporated in the discussion at the end of the thesis.

On the basis of comparative study, Neil et al (1938) introduced the "subapical" segment in their segmental pattern of the lower lobes, which, according to them, is constantly present in the human lung. In addition to the term "subapical", Neil, Gilmour and Gwynne (1939) coined the term "segmental bronchus" to replace the term "tertiary bronchus" of Kramer and Glass.

Lucien and Weber (1936) presented an entirely different scheme. They recognised a series of dorsal and ventral bronchi, which supply the dorsal and the ventral "territories". The branches of these bronchi supply the "internal" and

"external parabronchial territories", four main territories being recognised in each lung. According to them, these territories are constant but their bronchi are not.

Foster-Carter published his scheme of broncho-pulmonary segments in 1942 and 1943. He has maintained in each lung the concept of Aeby's stem bronchus having a dorsal and a ventral series of branches.

Foster-Carter and Hoyle (1945) described methods of investigating segmental anatomy and discussed the radiological aspects of the segments in addition to describing some minor subdivisions of the segments.

Foster-Carter (1946) has surveyed, largely on the basis of personal experience, some interesting common broncho-pulmonary abnormalities including abnormalities of lobes and fissures.

Appleton (1944) published an account of the broncho-pulmonary segments and blood vessels of the human lung as a prelude to more detailed account. He also studied the bronchoscopic appearances of the orifices of segmental bronchi. In 1945, he published a detailed account of the bronchi and blood vessels of the right upper lobe, and their variations in 50 specimens of human lungs. His untimely death brought to an end a work which would have rated as one of the classics.

Appleton coined the terms "subsegment" and "intersegmental plane", and introduced the concept of the "recurrent" and "ascending" arteries of the right upper lobe.

In Netherlands extensive work has been done by Huizinga and co-workers:-

Behr and Huizinga (1938) found, after a study in 108 right

upper lobes, that it is "not possible to indicate a scheme for the division of the lung segments", and that a fixed scheme cannot be given, although trifurcation of the lobar bronchus was found to be most frequent.

Huizinga and Behr (1940) found in 125 left upper lobes, 85 conforming to their pattern of segments which consists of an "apical" a "middle" and a "lower anterior" segment (obviously corresponding to the apico-posterior, the anterior and the lingula respectively). Their remaining 40 lobes showed variations.

In the left lower lobe, Huizinga and Behr describe only three segments, the "upper dorsal" (the apical segment), the "latero-ventral" (the anterior basal segment) and the "medio-dorsal" (the remaining lobe).

According to Pothoven and Huizinga, the number of broncho-pulmonary segments of the right middle lobe and right lower lobe are 2 and 5 respectively - in agreement with the international scheme.

So far, all investigators, who studied the bronchial tree, gave their respective bronchial or segmental schemes without actual demonstration of the extent and surface distribution of the broncho-pulmonary segments. To Brock goes the credit of demonstrating the broncho-pulmonary segments by injecting them with coloured gelatine. He is the first to demonstrate the variations of their size and shapes. In 1946, he published his monograph, a classic, on the "Anatomy of the Bronchial Tree - with special reference to the surgery of lung abscess", earlier published in parts in 1942, 1943 and 1944. Brock has given a most detailed

account of the bronchi and of broncho-pulmonary segments. His monograph contains excellent coloured plates illustrating the broncho-pulmonary segments. He has shown the importance of the axillary areas of the lungs. published since 1945.

In the first article, Boyden (1945) gave a detailed description of the broncho-pulmonary anatomy, a wide variety of nomenclatures had been introduced. Aeby, Ewart, Kramer and Glass, Nelson, Lucien and Weber, Peirce and Stocking, Churchill and Belsey, Neil and co-workers, Adams and Davenport, Foster-Carter, and Brock—all had suggested terminologies which differed from one another to varying degrees. The lack of harmony between various terminologies was beginning to be felt, and in 1942, Adams and Davenport pointed out the lack of an accepted bronchial nomenclature. In 1943, Jackson and Huber, in an important paper, discussed the anatomy of the bronchial tree and showed the inconsistency in nomenclature. They suggested a simple terminology indicating the positions of the segments in the lobes. Since then their terminology has been very widely accepted, and is in current use. (1947) and Boyden (1947).

In 1949, on the occasion of the International Congress of Oto-Rhino-Laryngology in London, an international committee discussed the terminology of the bronchial tree, and proposed an international nomenclature based on Jackson and Huber's nomenclature, with some minor modifications. This was accepted by the Thoracic Society. The report was published by Brock in "Thorax" (1950). Each segmental bronchus, according to this nomenclature, receives a standard number.

The most recent and the only detailed statistical work

on the anatomy of human lung, combining the study of bronchi and pulmonary vessels, is that done at the Minnesota Institute of Anatomy by Boyden and co-workers.

A series of articles have been published since 1945. In the first article, Boyden (1945) gave a detailed description of the bronchi and vessels studied in two pairs of lungs, and explained his terminology. He retained the nomenclature of Jackson and Huber, and explained his system of enumeration of bronchi, arteries and veins. He also defined the broncho-pulmonary segment, and considered that it is not a morphological broncho-vascular unit, a conclusion confirmed by the series of articles published later.

Boyden and Scannell (1948) analysed the broncho-vascular patterns of the right upper lobe, and established their prevailing patterns. Scannell and Boyden (1948) described the surface distribution of the segments in the same lobe.

The broncho-vascular patterns of the middle lobe were analysed by Boyden and Hamre (1951), of the right lower lobe by Ferry and Boyden (1951), and of the left upper lobe by Boyden and Hartmann (1946), Scannell (1947) and Boyden (1949).

The bronchi of the left lower lobe were analysed by Berg, Boyden and Smith (1949). The account of the vessels of the left lower lobe yet remains to be published. The writer is informed that the account of vessels of this lobe by Pitel and Boyden (1953) is in press (Boyden - personal communication).

The work of Boyden and co-workers has confirmed Jackson and Huber's classification, and shows the extreme complexity of the broncho-vascular patterns and their variations.

Table 1 . THE NUMBER OF BRONCHO-PULMONARY SEGMENTS OF HUMAN LUNG ACCORDING TO VARIOUS AUTHORS

AUTHOR	NUMBER OF SEGMENTS					
	R I G H T L U N G			L E F T L U N G		
	Upper Lobe	Middle Lobe	Lower Lobe	Upper Lobe - Upper Division	Upper Lobe - Lower Division	Lower Lobe
Kramer & Glass (1932)	4	2	5	4	2	5
Nelson (1934)	3	1	5 ("Dorsal"-1 "Lower"-4)	2	1	4
Huizinga & co-workers (1938, 1940, 1943)	2 or 3	2	5	2	1	3 ("Dorsal"-1 "Lower"-3)
Adams & Davenport (1942)	4	2	5	4	2	4
Foster-Carter (1943)	3	2	5	2	2	4
Jackson & Huber (1943)	3	2	5	2	2	4
Blades (1945)	4	2	5	4	2	5
Foster-Carter & Hoyle (1945)	3	2	5	2	2	5
Brock (1946)	3	2	5	3	2	4
Soulas (1948) (Segments called zones)	3	2	5	3	2	4 (sometimes 5 due to internal basal)
Neil & Gilmour (1949)	4	2	6	4	2	6
International Nomenclature (1949)*	3	2	5	3	2	4
Boyden & co-workers	3	2	5	2	2	5

* The Nomenclature of Bronchopulmonary Anatomy - Report by the Thoracic Society, Thorax, (1950), Vol 5/3 p.222-B, Brock.

They have also shown that the broncho-pulmonary segment, as stated before, should not be considered a morphological unit because the intersegmental planes are crossed by segmental arteries and drained by veins which are common to adjacent segments.

Boyden (1953) has raised some objections against the International Nomenclature. He disagrees with the recognition of the lateral segmental bronchus in the right upper lobe, and suggests that, according to his terminology, it should be called B^{3b}, as a side branch of B³ (anterior segmental bronchus). In addition he insists on the recognition of B⁷ (medial basal bronchus) on the left side as a segmental bronchus, earlier recognised by Ewart and Narath, and not recognised in the International scheme.

Boyden and co-workers recognised, in addition, a "more or less" constant "subsuperior zone in each lower lobe, even though it cannot be considered to be a segment because of its variable composition".

Thus the chief works in the field of variational anatomy of the lungs are those of Brock, and Boyden and co-workers.

The number of segments, into which each lobe of the human lung has been divided by various authors, are indicated in Table 1.

A study of their accounts shows that the differences in the numbers of segments are due to the following reasons:-

(1) In the right upper lobe the existence of the axillary segment (the lateral segment) has not been recognised by all. Behr and Huizinga, as mentioned already,

point out that it is not possible to divide the right upper lobe into a fixed number of segments. They divided the lobe into 2 or 3 segments depending upon the mode of division of the lobar bronchus.

(2) The right middle lobe has been left undivided by Nelson.

(3) In the right lower lobe, in addition to the generally accepted 5 segments, Neil and Gilmour have recognised a "subapical" segment.

(4) In the left upper lobe - upper division, some have recognised 3 - the apical, the anterior and the posterior, and some 4 segments - the additional segment being the axillary (lateral) segment, while others have only accepted 2 segments - the apico-posterior and the anterior.

(5) The left upper lobe—lower division (lingula) has been left undivided by Nelson, and Huizinga and Behr.

(6) In the left lower lobe some have recognised the usual 4 segments - the apical, the anterior basal, the lateral basal and the posterior basal. Others have recognised, in addition, the cardiac (medial basal) segment (B⁷ of Berg, Boyden and Smith), making a total of 5. Neil and Gilmour have added yet another segment, the "subapical". Huizinga and Behr have divided the left lower lobe into 3 segments only - the "upper-dorsal" (the apical), the "medio-dorsal" and the "latero-ventral".

Blood vessels of the human lung were described, in detail, first of all by Ewart (1889). Later they were described by Melnikoff (1924) and Backmann (1924), quoted by Appleton (1945).

by Adachi (1928 and 1933) has described the main pulmonary arteries and the pulmonary veins of the Japanese.

Herrnheiser and Kubat (1936) have given a most detailed account of the human pulmonary blood vessels, both arteries and veins.

Fleischmann (1950) has described the pulmonary veins.

Brantigan (1947) has described anomalies of the pulmonary veins.

Lindskog et al (1949) studied the anatomical variations of the vessels of the middle and lower lobes of right lung.

Brock (1940-1941) has given an account of the right and left pulmonary arteries.

Appleton (1944) has given a brief account of the pulmonary blood vessels. In 1945, he published a detailed account of the blood vessels of the right upper lobe. He was the first to make a combined study of the bronchi and vessels.

Recently Oliveros (1951) has given a detailed account of the arteries and veins of the human lung, taking into account the works of other authors.

The most recent and the most detailed statistical work is that of Boyden and co-workers, referred to already.

The only works which take into account the relation of vessels to bronchi are those of Appleton and of Boyden and co-workers.

Hilar anatomy has been dealt with by Rienhoff (1933), O'Shaughnessy (1935), Mason (1936), Crafoord (1938), Churchill (1940), Blades and Kent (1940, 1942a, 1942b), Miscall and Cornell (1943), and recently by Boyden and co-workers. Herrnheiser (1936a) has discussed the hilar anatomy in relation to roentgenography.

Fissures of the human lung have been studied by Blades and Kent (1942), Medlar (1947), Serova (1950) and briefly

by Berry and Childs (1932), by Brock (1946), Smyth (1949) and Dévé (1900) quoted by Brock (1946).

(5) With regard to the rudimentary fissures, the writer has not encountered any systematic study although their existence is frequently mentioned in literature. Foster-Carter (1946) has made a detailed survey of such fissures, based largely on examples encountered in the course of his routine clinical study and while investigating anatomy of bronchi. The commonly found fissures have been summarised in Cunningham's Text Book of Anatomy, 9th Edition, 1951.

Literature on the Lungs of Dog

A search for literature on the anatomy of dog's lungs has shown that the existing accounts are confined to the text-books of veterinary anatomy. A review of these accounts in the current text-books, (Sisson and Grossman, 1943; Bradley, 1948; Miller, 1949; Ellenberger and Baum, 1926) shows that the descriptions given are brief. The following gaps in the knowledge are noticeable:-

- (1) Only a general account of the external morphology of the lungs is given. The lobes have been named but none has been individually described.
- (2) Only the existence of "deep fissures" (Bradley, 1948) dividing the lungs into lobes is mentioned. The fissures have neither been named nor individually described.
- (3) Only the existence of "accessory fissures" as "most common in regard to the apical lobe" has been mentioned (Sisson and Grossman, 1943). No details are given.
- (4) The account of bronchi is restricted to their extra-

pulmonary portions. Their distribution in the lobes has not been considered.

- (5) Only the pulmonary trunk has been described. No consideration has been given to the right and the left pulmonary arteries and their intra-pulmonary distributions.
- (6) With regard to veins, apart from the statement of some facts, such as the root of the lung contains "several pulmonary veins", that the "number of openings from the pulmonary veins into the atrium is variable (three to five)", and that in the root the "pulmonary veins are most ventral", no more is given about them.

Aeby (1880), Narath (1901) and Huntington (1898) referred to the bronchial tree of dog briefly. Narath gave a brief general account of dog's lung and its lobes. His account of the bronchi is confined to the branches of the main stems. He has, in addition, given a brief account of the main arteries without referring to their branches except the infracardiac branch (artery of the intermediate lobe). He has not described the veins.

At the end it may be added that the concept of broncho-pulmonary segment, being too recent, has not yet found an application to mammals other than man. The only such instance encountered was an article by Stamp (1948) on "The distribution of the Bronchial Tree in the Bovine Lung". In this article Stamp gives no variations and has described only a single rigid pattern. The vessels have not been dealt with.

The work of Tonelli on dog, referred to already in the introduction, will be reviewed at the end.

The literature on the techniques used for investigating the anatomy of the lung, and a review of the current concepts of the broncho-pulmonary segments are given later. (pages 37 and 38).

Some species in this material represents the chief material among the primates, whose intrapulmonary anatomy is known to have been well worked out. Among the carnivores the dog may be considered as the chief representative whose bronchovascular anatomy has been worked out by the writer himself in detail, in a total of 37 specimens. Each of the remaining species is represented only by a single specimen.

The whole material consists of adults except a few young adults included among dogs.

Additional material used for some supplementary studies will be mentioned under the respective sections.

Techniques

Multiple methods, such as dissection, vascular cannulation, bronchography and bronchography, are known which can be employed for the investigation of the pulmonary anatomy. The present investigation is based on the use of the dissection method and the vascular cannulation method. The dissection method is used for the investigation of the bronchovascular anatomy and the vascular cannulation method is used for the investigation of the vascular anatomy. The dissection method is used for the investigation of the bronchovascular anatomy and the vascular cannulation method is used for the investigation of the vascular anatomy.

The nature of the present investigation requires the use of the dissection method and the vascular cannulation method. The dissection method is used for the investigation of the bronchovascular anatomy and the vascular cannulation method is used for the investigation of the vascular anatomy. The dissection method is used for the investigation of the bronchovascular anatomy and the vascular cannulation method is used for the investigation of the vascular anatomy.

MATERIAL AND METHODS

Material

The material comprises mammals belonging to the Orders, Carnivora and Primates. The details of the total number of specimens, the number of specimens dissected and the number of corrosion casts made, are set out in Table 2.

Homo sapiens in this material represents the chief mammal among the primates, whose intrapulmonary anatomy is known to have been well worked out. Among the carnivores the dog may be considered as the chief representative whose bronchovascular anatomy has been worked out by the writer himself in detail, in a total of 37 specimens. Each of the remaining species is represented only by a single specimen.

The whole material consists of adults except a few young adults included among dogs.

Additional material used for some supplementary studies will be mentioned under the respective sections.

Technique

Multiple methods, such as dissection, corrosion techniques, bronchography and bronchoscopy, are known which can be employed for the investigation of the pulmonary anatomy. The recent recognition of the bronchopulmonary segment has led to the development of some new methods for its investigation. Lastly there are methods which are the combination of two or more techniques which serve multiple purposes.

The nature of the present problem demands employing techniques suitable firstly for the study of gross anatomy of bronchi and pulmonary blood vessels, and secondly for demonstration of the bronchopulmonary segments.

Table 2. DETAILS OF MATERIAL

Total No. of Speci- mens	No. of dissected specimens	No. of Casts		Details of specimens in which bronchi, arteries and veins were studied			
		Single (bronchi only)	Triple (bronchi, arteries, & veins)	Bronchi		Arteries	
				Dissected specimens	Cast specimens	Dissected specimens	Cast specimens
37	14	19	4	14	23	14	4
1	-	-	1	-	1	-	1
1	-	-	1	-	1	-	1
5	-	2	-	-	5	-	2
1	-	1	-	-	1	-	-
1	-	1	-	-	1	-	-
1	-	-	1	-	1	-	1
47	14	23	7	14	33	14	9

Order Carnivora

Family Canidae

Canis familiaris
(Domestic dog)

Family Felidae

Felis catus
(Domestic cat)

Family Viverridae

Nandinia binotata
(Two-spotted Palm
Civet)Order Primates

Family Hominidae

Homo sapiens (Man)

Family Simiidae

Anthropopithecus
troglodytes
(Chimpanzee)

Family Cercopithecoidea

Macaca mulatta
(Rhesus monkey)Papio papio
(Guinea Baboon)

Total

The ideal methods for a primary investigation of the gross anatomy of the lung are dissection and preparation of corrosion specimens. The present study is based mainly on these two methods, but in two lungs of the dog the bronchopulmonary segments were demonstrated by the injection of coloured gelatine according to the method described later.

Methods used in this study are first briefly reviewed below.

Dissection

Ideally dissection should be performed on fresh specimens but as their preservation is usually essential it is performed on preserved specimens. This latter method has been extensively employed by Boyden and coworkers in their most detailed investigation of the bronchovascular anatomy of the human lung.

Use may be made of some stiffening media, injected into the bronchi or vessels prior to dissection. Appleton (1945) used coloured gelatine for the vessels of the lung. Scannell (1947) has described a technique of performing dissections after injecting the segments with coloured gelatine. Latex has been employed by Tobin and Zariquiey (1949, 1950). They used a differential injection method in which bronchi and vessels were injected with differently coloured latex, which can be combined with radio-opaque substances and radiographs taken before dissection.

Tobin (1952) has described a method in which after injecting various media, such as latex, vinyl acetate, gelatine or agar into pulmonary vessels, the lungs are dried in an inflated state by a continuous stream of compressed air into the respiratory tissue. The dried lungs can then be dissected to show the course and relations of blood vessels and bronchi. Again roentgenograms can be taken by incorporating radio-opaque substances.

In the present study plain dissections were preferred and successfully performed on lungs preserved in 5% formaldehyde. Experimental dissection, attempted after injecting differently coloured gelatine into bronchi and vessels, was found to be tedious and the preservation of small structures was difficult. They were damaged by being pulled out with the gelatine which tended to come off in small chunks.

Corrosion Techniques*

A large number of injection media have been employed since the first corrosion experiment was done by Govard Bidloo (1649-1713). It is interesting to note that he did this on a lung. He used "fused bismuth", a mixture of bismuth and mercury, and removed the soft parts by corrosion. Since then metals of different compositions and melting points have been used for the preparation of cast.

William Cowper (1698) used an alloy of "block tin" (pure tin) for preparing lung casts and macerated off the soft parts.

Homberg (1699) used a metal of low fusibility consisting of equal parts of lead, tin and bismuth for vessels, followed by corrosion.

Valentin (1720) prepared casts by injecting low fusible metal for lungs and blood vessels, followed by boiling away the soft tissues.

* F.J. Cole, in Singer's "Studies in the History and Method of Science" (1917-21), gives an excellent account of the history of anatomical injections from the middle of the seventeenth century up to 1843. For this period information has been extracted from his account.

Straus-Durckheim (1843) gave a formula for his fusible metal, consisting of bismuth lead and tin with mercury added to reduce the melting point.

Aeby (1880) used "Rose's metal mixture" (composition not given) for lungs which were injected in situ. He macerated the soft parts.

Ewart (1889) used a fusible metal, consisting of tin, lead, bismuth and cadmium with a melting point of 158°C. for lungs which he also injected in situ.

Peterson (1935) used Wood's metal with a melting point of 65°C. for lungs.

Neil and co-workers (1938) also used Wood's metal.

Metal has recently been used by Brock (1942, 1943, 1944), the composition of which has not been mentioned.

Smyth (1949), using a fusible metal of an unknown composition, has described in detail a technique of preparing lung casts.

The use of some plastic substances has been introduced recently, of which celloidin has been the most commonly used. It was used by Hyrtl (1860) for injecting blood vessels of the kidney. Schiefferdecker (1882) used celloidin in ether coloured with asphaltum, and Hochstetter (1886) combined celloidin with kaolin (quoted by Narat, Loef and Narat, 1936).

Krassuskaja (1904) used celloidin with camphor which renders the cast less brittle. He employed cinnabar for colouring the celloidin red and Berlin blue for blue.

Huber (1906) substituted alkanin for cinnabar.

Hinman et al (1923) have described a method for injecting blood vessels, employing celloidin prepared by using X-ray films and camphor in acetone.

Celloidin was also used by Foster-Carter (1942, 1943), who has described a method of preparing lung casts by injecting bronchi in situ.

Another plastic substance, recently introduced for the preparation of casts, is a solution of "Vinylite" in acetone. The method has been described by Narat, Loef and Narat (1936).

Puckett and Neuman (1940) described a technique of using multicoloured vinylite, whereby a corrosion cast of the vessels of an entire animal can be obtained. Their method was employed by Marchand, Gilroy and Wilson (1950) for the pulmonary vessels.

Liebow et al (1947) have described a technique for preparing lung casts, using 10-15% vinylite coloured with different dyes. Radio-opaque substances can be added.

The most recent and an ingenious technique is that of Tompsett (1952) who has introduced the use of a new plastic, "Marco Resin (26 C)" for preparation of human lung casts. His technique will be briefly described later. It has certain definite advantages over others, and has been employed in this study for preparation of some of the casts. The remaining casts were made of celloidin.

One of the other substances mentioned in literature which have been used for preparing casts is "Polythene", an I.C.I. product, mentioned by Smyth (1949) who found it unsuitable for lungs. Latex may be used, but its great penetrating power and its soft rubbery consistency would make it unsuitable for the bronchi.

Techniques Used for Demonstrating Bronchopulmonary Segments

Different methods have been used for outlining territories

supplied by the bronchi in the lungs.

Kramer and Glass (1932), who originally defined the bronchopulmonary segment, injected coloured fluid dyes into segmental bronchi of lungs kept inflated by a constant stream of air.

Macklin (1936) outlined a certain territory supplied by a "secondary bronchus" of a previously warmed dog's lung in order to study alveolar pores.

Behr and Huizinga (1938) outlined segments by injecting paraffin coloured with Prussian Blue and "imitation carmine".

Brock (1946) injected differently coloured gelatine solutions to demonstrate segments permanently.

Foster-Carter (1942) used preservative solutions coloured with water soluble dyes in order to outline segments on the surface of the lung. He also used simple inflation with air by means of a syringe, but Neil and Gilmour (1949) found that this method produced emphysema.

Neil et al (1938) advocate demonstrating the segments by inflation in lungs previously fixed by the method described by Mooltan (1935). Their method was found to be the best by Jackson and Huber (1943).

Lastly there is the "segmental deflation" method for use at the operation table, described by Nelson (1940).

Bronchopulmonary segments can also be demonstrated by dissection. The presence of intersegmental planes in the human lungs facilitates this procedure, but the absence of any such visible planes in the dogs' lungs was found to make this method difficult.

Dissection was done on the individual lobes. It was completed at the hilum and was completed by picking out the lung parenchyma with an ordinary pair of dissecting forceps. Margins of lung segments

Details of the Methods Adopted

Removal of Lungs

The thoracic viscera were removed enmasse along with the trachea. During their removal aberrant pulmonary blood vessels were carefully looked for. No such vascular anomalies were found in the material used. All lungs were carefully examined for any evidence of disease.

1. Dissections

Fifteen pairs of lungs, of freshly killed dogs, were preserved in 5% formaldehyde. One of these pairs was hurriedly dissected to obtain a general idea of the internal arrangement of structures. The remaining 14 pairs of lungs (98 lobes in all) were then dealt with according to the following plan:-

The thymus and the pericardium were removed. The pulmonary trunk was sectioned distal to the pulmonary valves. The wall of the left atrium was then snipped and cut all round, close to the entrance of pulmonary veins. The heart was thus detached along with the aorta and the venae cavae, leaving the dorsal wall of the left atrium behind (Fig.36A). After studying the modes of entrance of the lobar veins and the arrangement of their orifices in the atrium, the remaining part of the atrium was removed by dividing the pulmonary veins. This exposed the right and the left pulmonary arteries and the two main bronchi. Their branches were then traced up to the hilum of each lobe. (Figs.36B, 37, 38 and 39)

After completing the observations on the pulmonary roots and hila, the lobes were detached from each other and thereafter the dissection was done on the individual lobes. It was commenced at the hilum and was completed by picking out the lung parenchyma with an ordinary pair of dissecting forceps. Margins of lung tissue

were left undissected along the peripheral borders of the lobes so that the ends of bronchi and vessels remained fixed and their relations were maintained. At the end of the dissection the lobes assumed a very flat appearance due to its being deprived of its "padding"

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dyes and is used at room temperature. Above all it is light and

not brittle. It has the disadvantage of shrinking and therefore

the casts undergo distortion. Its use, as described by Linbo et

al, needs an elaborate apparatus. However, the operation of its

use has not been due to its non-availability at the time when

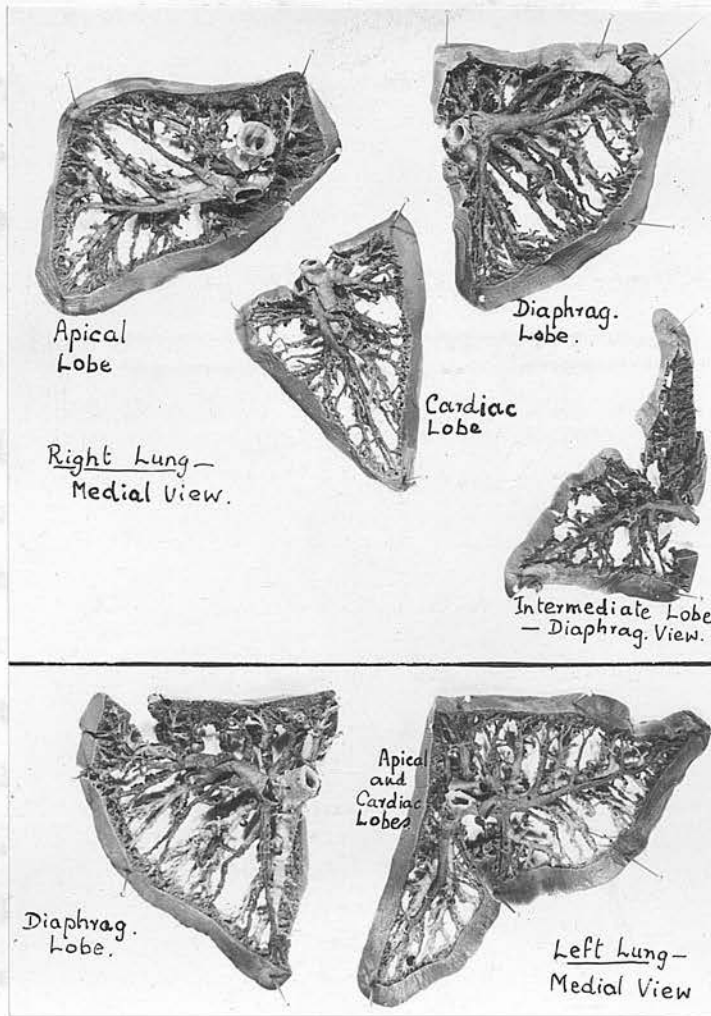


Fig. 1 . A typical dissection of a preserved pair of lungs of dog.

vinyl, etc.

penetrates well, etc rapidly, but without dissection and

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were left undissected along the peripheral borders of the lobes so that the ends of bronchi and vessels remained fixed and their relations were maintained. At the end of the dissection the lobe assumed a very flat appearance due to its being deprived of its "padding" formed by the lung parenchyma. Due to the same reason some disorganisation of the relative positions of the structures was inevitable. For the sake of clarity it was only possible to retain the main bronchi and vessels. Some of the minute branches had to be severed. The end result of such a dissection is shown in Fig. 1 .

2. Corrosion Preparations

The choice of selection of injection material lay at the time of starting the work between fusible metal, celloidin and vinylite.

The use of fusible metal demands an elaborate apparatus. The injections into the bronchi are done with the lungs in situ. The vessels cannot be injected at the same time. The casts are too heavy. A good human lung cast weighs 12 - 15 lbs. (Peterson, 1935). The metal cannot be coloured. If it penetrates too deep, pruning is difficult. It may on the other hand fail to penetrate into small branches. For these reasons this technique was not considered.

Vinylite, popular in America, has certain advantages. It penetrates well, sets rapidly, can withstand dissection and chemical corrosion (Tobin, 1947). It can be coloured with fast dyes and is used at room temperature. Above all it is light and not brittle. It has the disadvantage of shrinking and therefore the casts undergo distortion. Its use, as described by Liebow et al, needs an elaborate apparatus. However, the question of its use did not arise due to its non-availability at the time when this

work was started. Consequently the only choice was the use of celloidin.

The principle underlying its use is that when a solution of celloidin in acetone or ether, the former being more commonly used, is injected into bronchi or blood vessels, the solvent, in the presence of water, readily diffuses out, leaving a precipitate which gradually hardens. The soft tissues are then macerated by corrosives, pure hydrochloric acid, weak hydrochloric acid with pepsin or potassium hydroxide being in common use.

Celloidin is easy to handle. It is used at room temperature. It can be coloured with fast dyes and needs a simple apparatus. Some of the disadvantages of celloidin often mentioned are that it "discolours, cracks, becomes distorted after a time" (Smyth, 1949). Some celloidin casts preserved in the Anatomical Museum of Edinburgh University, made in 1939 by Ross, were found by him in as satisfactory a condition in 1946 as seven years earlier. To-day, in 1953, as confirmed by him, they are still in an excellent condition. Some celloidin lung casts preserved in the Anatomy Department of the Royal (Dick) Veterinary School for over two decades are still in good condition. The writer himself has observed no distortion or cracking of the lung casts prepared two years ago. Their handling needs only a moderate amount of care. Only the very fine branches are brittle. The larger branches are firm and strong.

No single corrosion technique could be adhered to because the size of the lungs used for the preparation of casts varied very considerably, and also because the material consisted of fresh lungs as well as lungs removed from embalmed animals.

Most of the specimens were prepared using celloidin. Some

were made of "Marco Resin", using Tompsett's technique described later.

Techniques Employed for Preparing Celloidin Casts *

Four different methods had to be tried for preparing Celloidin casts.

(1) Foster-Carter's Technique for Bronchi

Foster-Carter's method of preparing human bronchial casts consists of the following steps:-

1. The trachea is opened in the neck.
2. The bronchi are washed with water to remove mucous, employing a bronchoscope.
3. A large glass cannula is tied into the trachea and is connected by a wide-bore rubber tubing to a funnel fixed one foot above the neck.
4. The injection mass, consisting of X-ray film 20 gms., camphor 15 gms. and acetone 100 cc., is poured down the side of the funnel, thus expelling as much air as possible from the trachea and bronchi.
5. Twenty-four hours are allowed for setting, more mass added if necessary.
6. The viscera are carefully removed from the thorax.
7. The viscera are then suspended in a large vessel containing hydrochloric acid, in such a way that the bases of the lungs barely float. More acid must not be added at this stage lest the lungs float outwards and the cast be distorted.
8. On the following day and on each subsequent day until completion, the viscera are lifted out of the acid and the macerated parts are

* Celloidin was prepared by using old non-safety cinematograph film made of celluloid nitrate, according to the method given by Hinman et al.

washed off with a fine jet of water. The organs are then replaced and more acid is added until lungs barely float.

The whole process takes about 10 days.

Four pairs of lungs were injected by this method but step 2. was omitted, and the immersion of the specimen in strong hydrochloric acid for 24 to 36 hours was found to be sufficient for maceration. It was found that the penetration of the injection mass was inadequate in these four specimens. Ten % celloidin was, therefore, substituted and another 10 specimens injected. Only two successful and two partially successful results were obtained. The remaining casts were either completely or partially solid.

In an attempt to get improved results this method was modified and is described next.

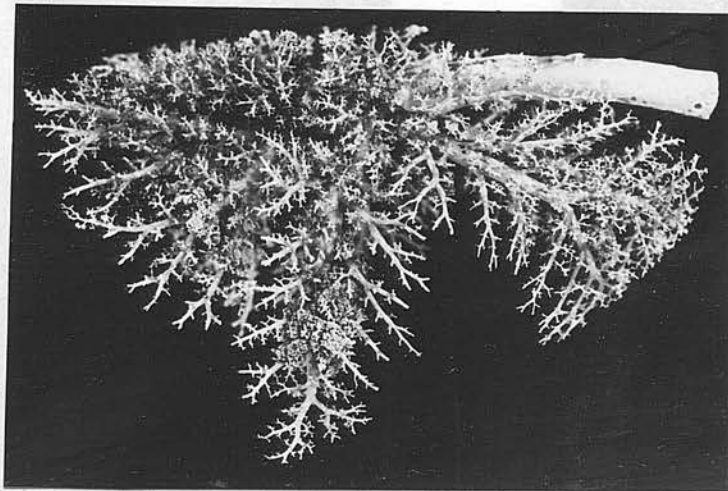
(ii) Foster-Carter's Technique for Bronchi - Modified by the Writer

Due to the inconstant results obtained by injecting the lungs in situ, the same method was applied to lungs removed from the thorax. They were floated in water to help the celluloid precipitate quicker before it penetrated too far and produced solid patches.

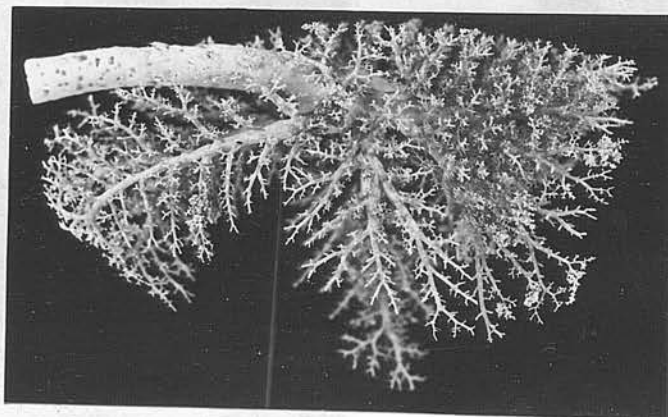
Ten % celloidin was used and 8 lungs were thus injected. Three successful and 5 partially successful results were obtained. In general the results obtained by this method were better, but the casts produced did not possess the normal shape as it was difficult to maintain the lungs in the normal position in water.

(iii) Preparation of Celloidin Bronchial Casts by Writer's Own Method

It was found that when celloidin is injected into a pair of lungs through the trachea, within a short time of its having reached under the pleura, it forms multiple white spots which may



A. Right Lung

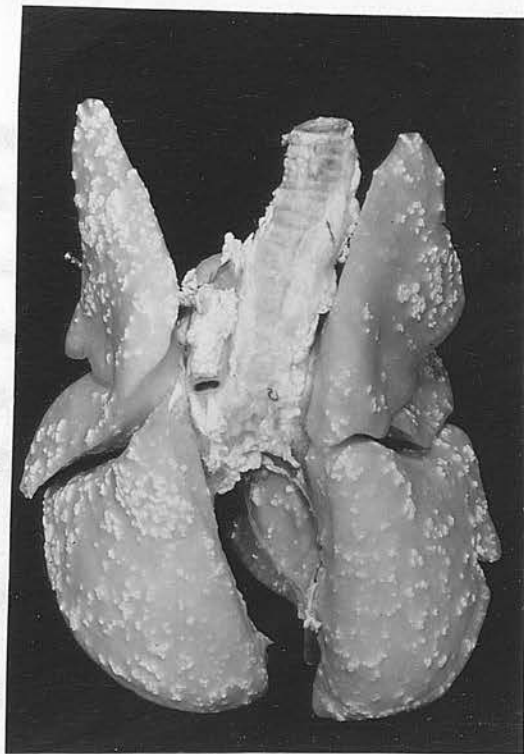


B. Left Lung

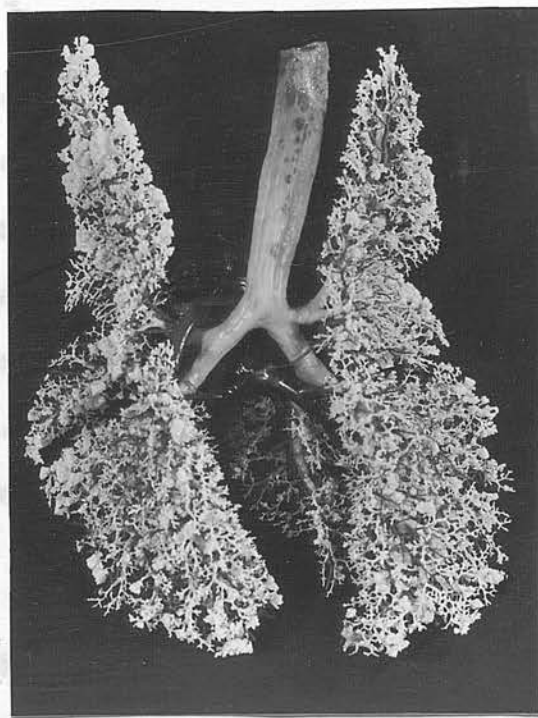
Fig. 2 , A & B. A Celloidin cast of the Bronchial Tree of Dog, prepared from a pair of lungs hardened in situ (Specimen E53).

A. Dorsal View. B. Ventral View.

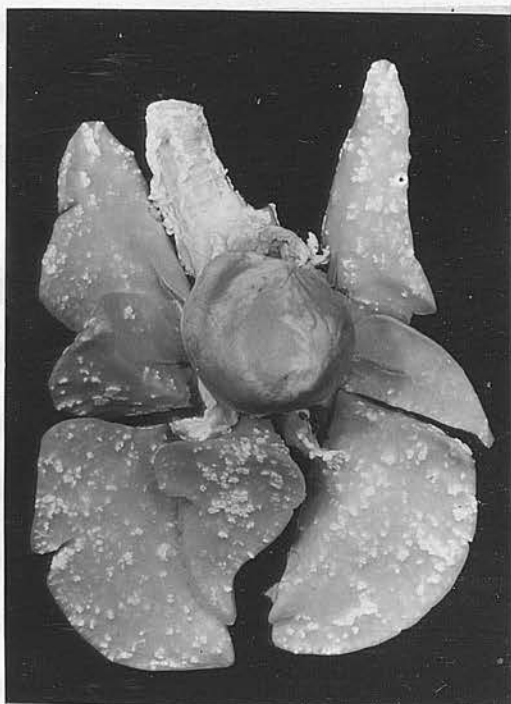
C & D. The Tracheal Celloidin cast obtained after dissection, and pruning away much of the system.



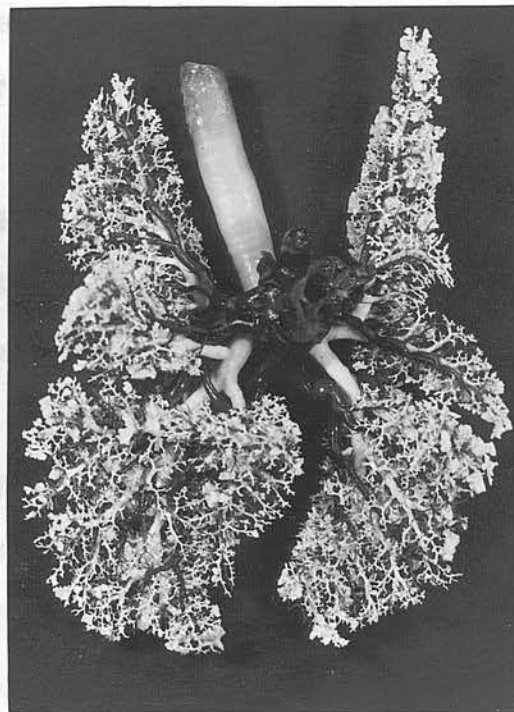
A



C



B



D

Fig. 3 , A, B, C, D.

A & B. The appearance of subpleural white spots of celloidin, shortly after injection of the bronchial tree in a fresh pair of cat's lungs. A, Dorsal View. B, Ventral View.

C & D. The Triple Celloidin cast obtained after maceration, and pruning away most of the spots.

appear simultaneously. These patches appear within a few seconds if the lungs are kept in water to keep the pleura wet. The appearance of these white spots is shown in Figs. 3A and 3B in a fresh pair of cat's injected lungs. Similar spots, but not so uniformly distributed, were found to appear when a pair of lungs removed from an embalmed animal was injected.

Two simple methods used, based on the above observation, are described next.

(a) Preparation of Celloidin Bronchial Casts of Lungs Hardened in Situ

In order to prepare casts which reproduced the natural shape of lungs, it was decided to attempt using lungs removed from embalmed animals. After a few experiments the following simple technique was worked out:-

The hardened thoracic viscera were carefully removed en masse. By means of a glass cannula, tied into the trachea and a rubber tube attached to its other end, air was blown in and out a number of times to ensure that all parts of the lung moved uniformly and that all bronchi were patent. The rubber tubing was then detached and 10% celloidin was gradually poured along the side of the cannula till the trachea and the cannula were full. A metal syringe of a capacity of 80 cc., which was kept ready filled with 10% celloidin, was then attached to the cannula by means of a short piece of rubber tubing. Care was taken that no air bubbles got trapped.

The injection was then commenced. A gentle pressure was maintained on the piston of the syringe so that the celloidin was very slowly and continuously injected. The pleura was watched carefully all along for the appearance of the white celloidin spots. The first appearance of one or more of these patches was taken as

an indication that the injection mass had penetrated throughout the lung. The injection was then stopped, the rubber tube clamped and the syringe detached. The lungs were left in water for about 20-30 minutes to let the celloidin set in the smallest bronchial tubes and thus block them, so that no further penetration of celloidin could take place.

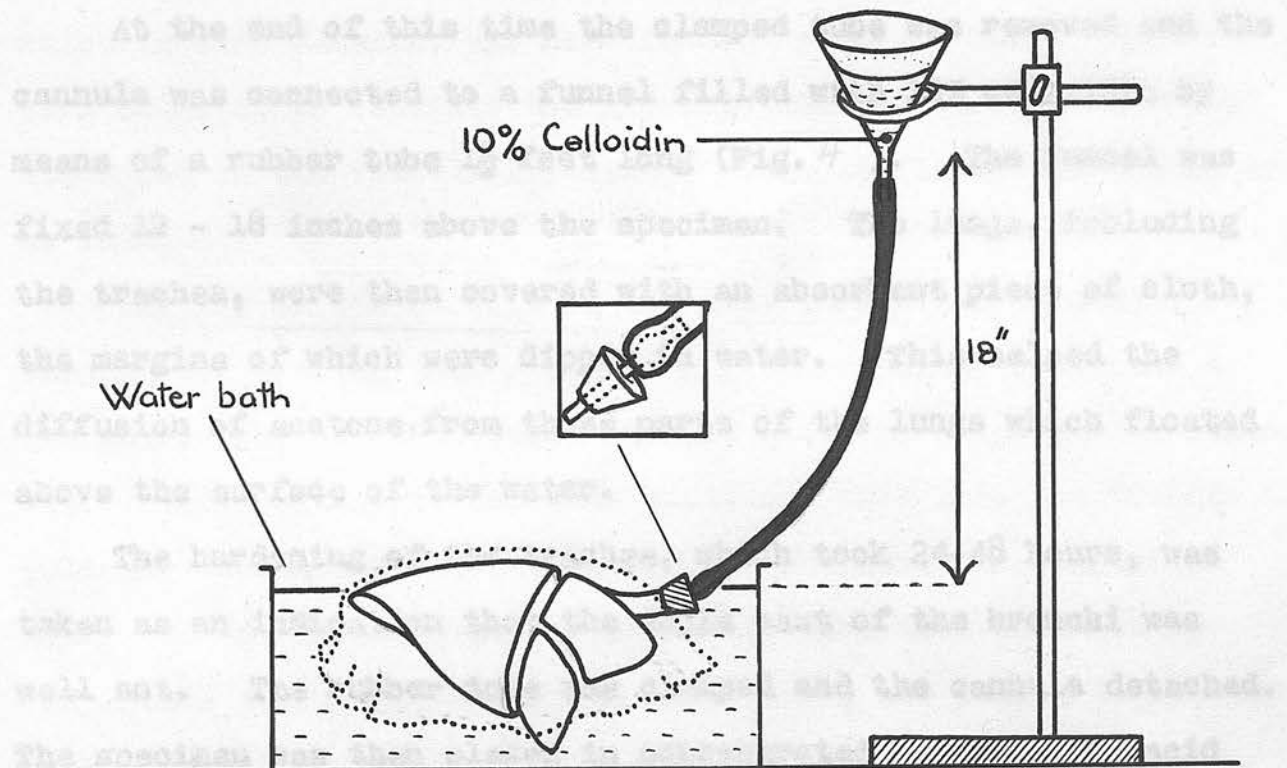


FIG. 4 Apparatus set up after injection of 10% celloidin into lungs

This method was applied to 15 pairs of lungs. The results were successful except that in one pair of lungs, the celloidin was imperfectly injected.

an indication that the injection mass had penetrated throughout the lung. The injection was then stopped, the rubber tube clamped and the syringe detached. The lungs were left in water for about 20-30 minutes to let the celloidin set in the smallest bronchial tubes and thus block them, so that no further penetration of celloidin could take place.

At the end of this time the clamped tube was removed and the cannula was connected to a funnel filled with 10% celloidin by means of a rubber tube $1\frac{1}{2}$ feet long (Fig. 4). The funnel was fixed 12 - 18 inches above the specimen. The lungs, including the trachea, were then covered with an absorbent piece of cloth, the margins of which were dipped in water. This helped the diffusion of acetone from those parts of the lungs which floated above the surface of the water.

The hardening of the trachea, which took 24-48 hours, was taken as an indication that the whole cast of the bronchi was well set. The rubber tube was clamped and the cannula detached. The specimen was then placed in concentrated hydrochloric acid and after 48-72 hours, depending upon the size of the lungs, the macerated tissue was washed away with a fine jet of water. The cast was then immersed in water for a few days, the water being changed frequently for the acid to diffuse out.

Two of the casts obtained by this method are shown in Figs. 2 and 72.

This method was applied on 12 pairs of lungs. All results were successful except that in one pair of lungs, one ^{of the} lobes was imperfectly injected.

(b) Preparation of Triple Celloidin Casts
(Bronchi, Arteries and Veins)

The foregoing method cannot be used for the injection of vessels for which fresh lungs have to be employed so that blood can be washed out.

As before, 10% celloidin was used. Blue celloidin, coloured with Berlin Blue, was used for the arteries and red celloidin, coloured with alkanin, was used for the veins. These colours were selected to indicate the physiological colours of the blood contained in the vessels injected. The details of the method are as follows:-

The tip of the auricle of the left atrium was removed. Through the opening thus produced a glass cannula, connected to the water-tap, was introduced and the clots of blood gently washed out. Three cannulae were then tied, one each into the trachea, the pulmonary trunk and the left atrium. The aorta was ligatured distal to the aortic valve. The lungs were then perfused by Tompsett's technique, described on page 50, and placed in a water bath.

It may be pointed out here that in the preceding technique some celloidin was first poured into the trachea before injecting it with the syringe. In the present method the lungs having been perfused, the bronchial passages are full of water. If celloidin be poured first it would undergo precipitation in the main passages immediately and the precipitated flakes of celloidin would obstruct the progress of celloidin when injected with the syringe. No celloidin was therefore poured into the trachea. During and after perfusion care was taken that no air entered into bronchial passages. Small quantities of air, collected in the alveoli from the tap water used for perfusion, however, did not

matter. A short rubber tube, about 6 inches long, was attached to the cannula in the trachea and filled with water to exclude air. A large metal syringe, of a capacity of 130 cc. with a nozzle attached, was then filled with 10% celloidin. The next step of the actual injection needed a speedy performance. The nozzle of the syringe was fixed into the rubber tube attached to the cannula in the trachea, avoiding any trapping of air bubbles, and the injection was commenced immediately. A quantity of celloidin, the amount of which was judged according to the size of the lungs, was injected with a greater initial force so that the celloidin quickly reached the periphery of the lung before it had had time to precipitate in the main passages.

As soon as the celloidin reached the pleura it showed itself, as stated before, by forming multiple sub-pleural patches (Figs. 3A and 3B). After the appearance of these spots the same procedure was adopted as has been described in the previous technique.

After completing the injection of the bronchi, the vessels were injected with coloured celloidin using the same syringe. As soon as coloured celloidin penetrated into the vessels, the lung became uniformly coloured; red, when the veins, and blue, when the arteries, were injected. At the same time the injected arteries and veins could be seen under the pleura as parallel streaks along the thin margins of the lobes. Immediately after the injection of the vessels, the same funnel and tube arrangement was set up as for the bronchi, one funnel containing blue celloidin for the arteries, and one containing red celloidin for the veins.

While the lungs were still soft, i.e., immediately after the injections, the lobes were arranged in water in as natural a

position as possible. This was attained to varying degrees in different lungs. It may be noted that the lungs had to be floated in water with their ventral side up.

Within 24 to 48 hours, when the trachea was hardened, cannulae were disconnected and the lungs macerated in hydrochloric acid and washed. Six casts, one each of a cat, a civet, a baboon, and of three dogs, were prepared by this method. These casts were so completely injected that they needed pruning in order to expose the gross structures which were to be studied.

Figs. 76A and 76B show a triple cast prepared by this method.

Tompsett's Technique of Preparing Marco-Resin Casts

Five human and three dogs' lung casts were prepared by Tompsett's technique. Some of the casts so prepared are shown in Figs 5, 6, 7, 8. His technique consists of using Marco-Resin S.B. 26 C., an unsaturated polyester, which sets by polymerisation under the influence of a catalyst. It can be coloured differently by using "Marco pigments".

Tompsett's ingenuity lies in his evolving a technique which prevents the resin to flow into the alveoli. His technique as described for the human lung consists of the following principal steps:-

1. Fresh healthy lungs are perfused by running cold water from the tap into the trachea and allowing it to escape via the arteries and veins after diffusing through the walls of the alveoli.
2. By alternate inflation and deflation of the lung with carbon dioxide and final running of cold water through the lungs to absorb CO_2 , air is eliminated.
3. Lungs are preserved in 70% spirit to fix them. The remaining steps given below are completed on the day of the injection.

4. Spirit is washed out and air is eliminated as before with carbon dioxide, if necessary.

5. Lungs are placed in a water bath at 33°C . This temperature is maintained till the injection is completed.

6. Lungs are placed on a plaster mould, shaped in the form of posterior thoracic wall, under water in the bath. Water at 33°C . is run through the trachea to warm the lungs.

7. About 5 litres of gelatine solution, with a gelling point of about 28°C ., is poured into the trachea till the lungs are quite turgid and fully expanded.

8. The temperature of the water bath at 33°C . prevents gelling of the gelatine, some of which diffuses out through the pleura.

9. As much of the gelatine as the total amount of resin which is estimated to be run in is first syphoned out and the resin is then let in.

For a triple cast of bronchi, arteries and veins known quantities of Marco-Resin, clear resin for the bronchi and coloured for arteries and veins, whose setting times are previously worked out by special tests, are run in simultaneously. The resin is allowed to flow into the lungs about 6 minutes before the expected setting time. The resin being immiscible with gelatine is prevented by the latter from running too far into the alveoli.

Immediately 400 ml. have entered the bronchi the tube into the trachea is clamped and the temperature of water bath lowered by adding a large quantity of ice. This hurries the setting of gelatine and prevents further penetration into peripheral alveoli.

The flow of resin into vessels automatically stops after 2 minutes.

10. The specimen is left in water for a week to let the resin harden.



11. The specimen is then washed in running water at a temperature of not more than 40°C. for 2 days to allow the gelatine to diffuse out.

12. Maceration is done in concentrated hydrochloric acid for 24 - 48 hours.

13. The cast is then washed with a jet of hot water.

14. Surplus resin which has run into the alveoli is then removed by a process of pruning.

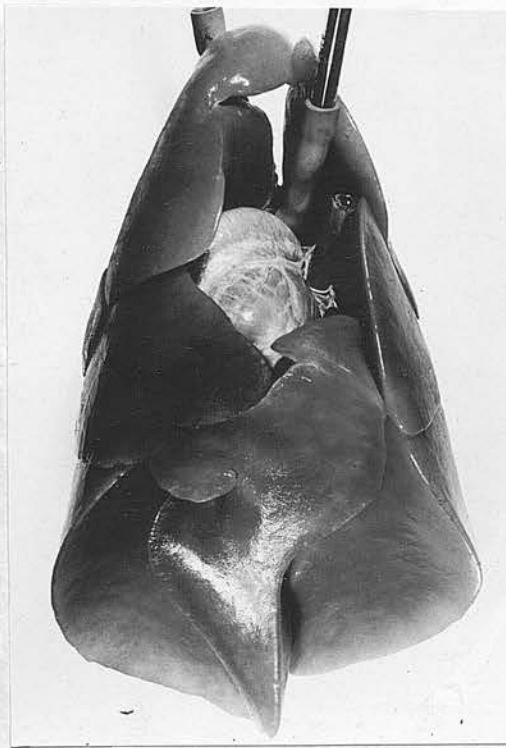
The various steps of this technique are illustrated in Figs. 5A to 5C.

The advantages of the above technique are:-

1. No complicated apparatus, such as used for Wood's metal and vinylite, is required.
2. Although the lungs are handled outside the lung, the casts obtained exhibit a perfect anatomical shape.
3. The casts obtained are completely injected.
4. The element of chance, inherent in other techniques, is reduced to its minimum.
5. The results are most attractive.

However, "the labour involved, and the considerable skill required", and the tedious and time-consuming pruning, which may take up to 2 weeks for a triple cast, are the chief disadvantages. The casts at room temperature are brittle and need very careful handling.

One advantage of this technique, which the writer noticed, is that due to the bronchial tree having been injected almost up to the alveoli, it is possible to study the surface projections of the various bronchopulmonary segments - an excellent opportunity for studying the morphology of the bronchopulmonary segment.

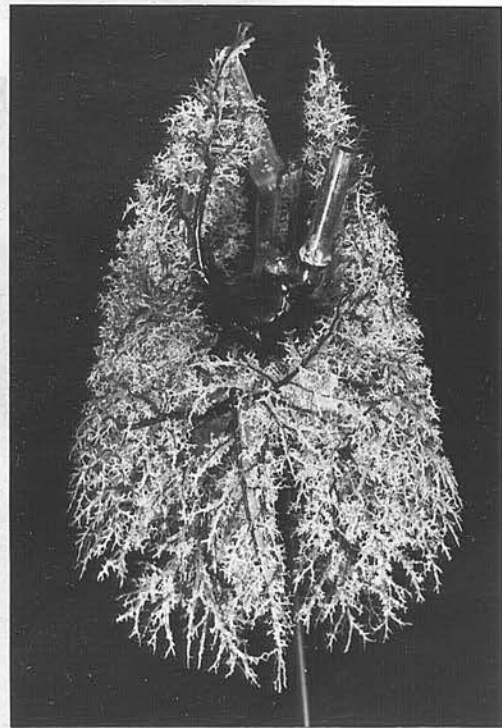


A

Fig. 5.
Bronchi and
Pulmonary
Arteries.



B



C

Fig. 5. A, B & C. Steps of preparation of a Triple Marco Resin cast of a pair of Dog's lungs (Specimen E56), using Tompsett's technique for Human Lungs.

- A. Immediately after injection of resin - Ventral View.
- B. After maceration and washing of the specimen.
- C. The finished cast after pruning.

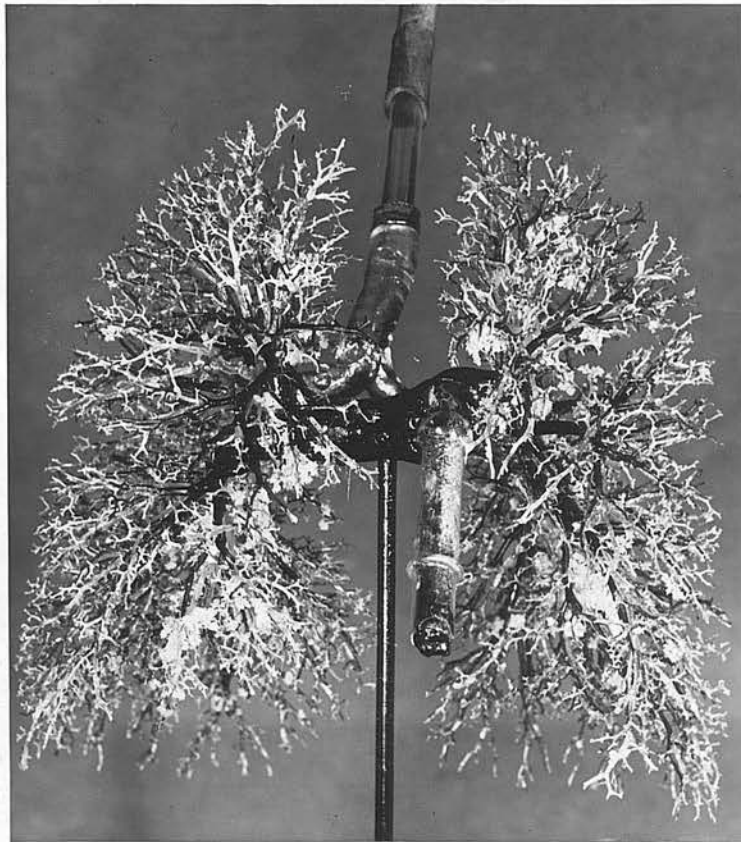


Fig. 6.
Bronchi and
Pulmonary
Arteries.

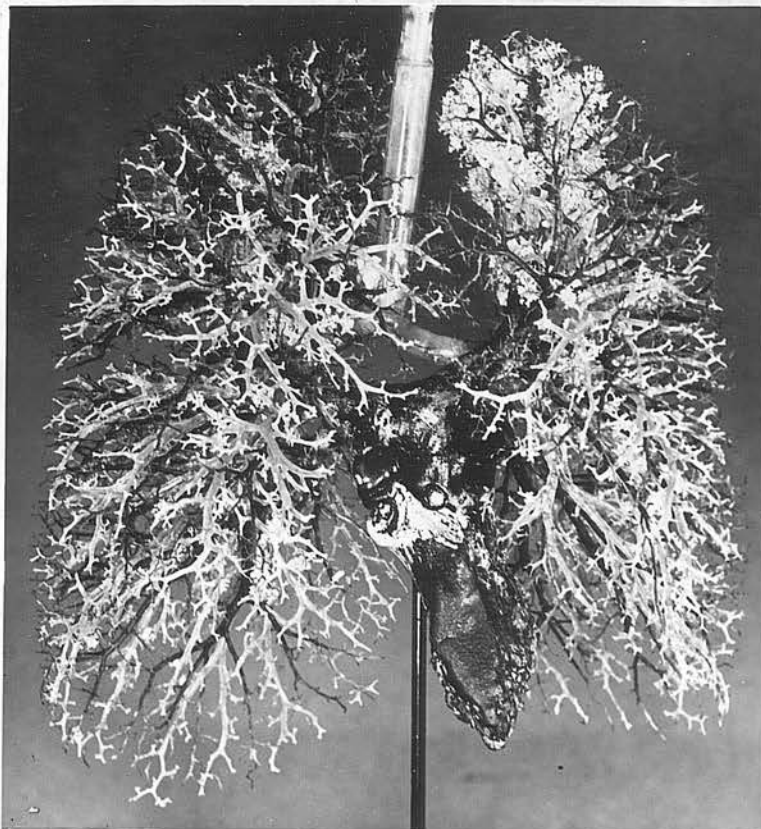


Fig. 7.
Bronchi and
Pulmonary
Veins

Figs. 6 & 7 . Marco Resin Casts of
Human Lungs prepared by
Tompsett's technique.

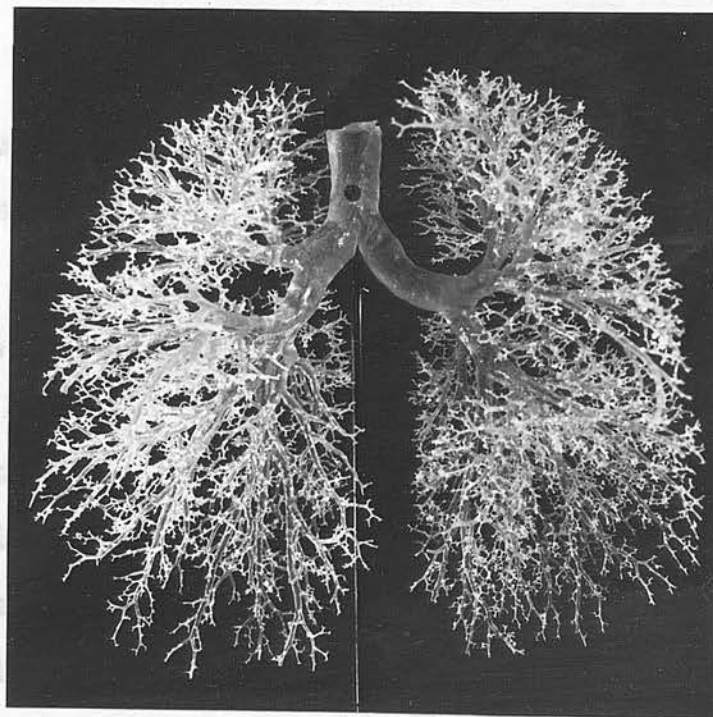


Fig. 8 Ventral view of a cast of the Bronchial Tree of Human Lung, prepared by Tompsett's technique.

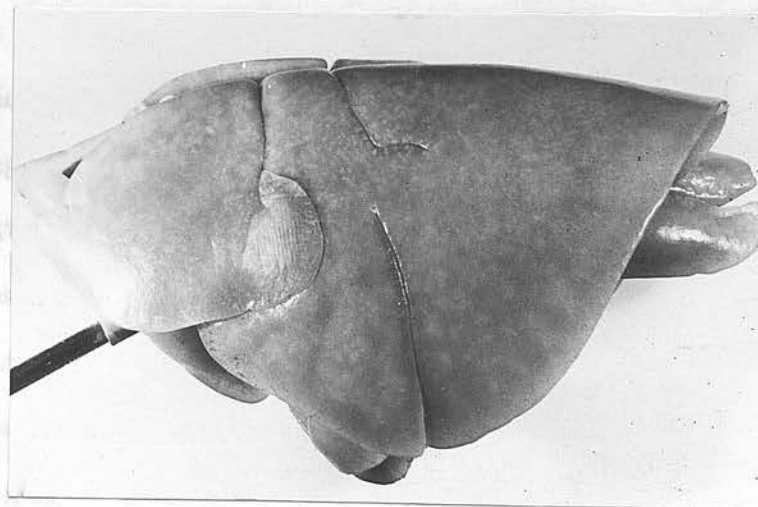


Fig. 9 . Costal view of the left lung of the specimen shown in Fig. 5A . 1. Band of lung tissue obliterating the major fissure. 2. Rudimentary fissure between segments D_1 and D_2 of left apical lobe.

3. Permanent Demonstration of Segments
by Injection of Coloured Gelatine

The bronchopulmonary segments of two fresh pair of lungs (14 lobes in all) were injected with 15% gelatine solution (gelling point 32° - 34°C.), coloured with Monolite fast dyes available in yellow, red, blue and green colours. A metal syringe of a capacity of 130 cc. was used to which was attached a short piece of rubber tubing.

Multiple glass cannulae, with bulbous ends of different sizes, were prepared to fit into the segmental orifices in such a way that the bulb fitted tightly into the orifice to be injected. No ligatures were used. The following procedure was adopted:-

The lobes, except the left apical and the cardiac, which are partly fused together, were separated from each other. The lobe to be injected was placed in a tray and its bronchus opened, as shown in Figs. 32B and 33B.

It was not possible to open the bronchus without doing some degree of damage to the overlying lung tissue, but care was taken not to damage the bronchial orifices.

A tightly fitting cannula was gently pushed into the bronchial orifice so that it was held in place by the elasticity of the bronchial wall.

A rubber tube was attached to the cannula and air gently blown into it. The inflated segment was then outlined by an indelible pencil. The segment was then allowed to collapse. Water at 35°C. was then run into the segment to warm it up, and immediately afterwards liquid gelatine, at over 35°C. , was injected till the previously outlined segment was moderately distended. Over distension was avoided. Without removing the cannula or

the syringe, the lobe was plunged into cold water in a sink for about 15 minutes till the gelatine was set. The syringe was then disconnected and the cannula removed.

The same procedure was repeated for each segment using different colours.

The mixing of colours on either side of the indelible pencil lines could not be avoided despite using very gentle pressure. Whether it was due to damage to the delicate alveolar walls, or due to intra-alveolar pores, it is not possible to say.

After injection of the whole lobe, it was placed in 5% formaldehyde and on a subsequent day before the indelible marks faded the lines were redrawn with waterproof Indian ink after drying the surface of the lobe.

The method was found extremely tedious and the results were not according to expectation. It was found that demonstration of the segment by blowing air is a more satisfactory and reliable method, although it was found in one pair of lungs of dog, not included in this study, that it was extremely easy to produce emphysema.

Terms, "proximal" and "distal", have also been used in order to refer to the parts of spaces between two adjacent branches of what will be described as the "lobar stem bronchus" (the central axial bronchus of a lobe from which branches arise in series). By proximal part of a space will be meant the part which is nearer the lobar stem bronchus, and by the distal part, the part which is nearer the peripheral border of the lobe, i.e., away from the lobar stem bronchus.

The above points are schematically illustrated in Fig. 10.

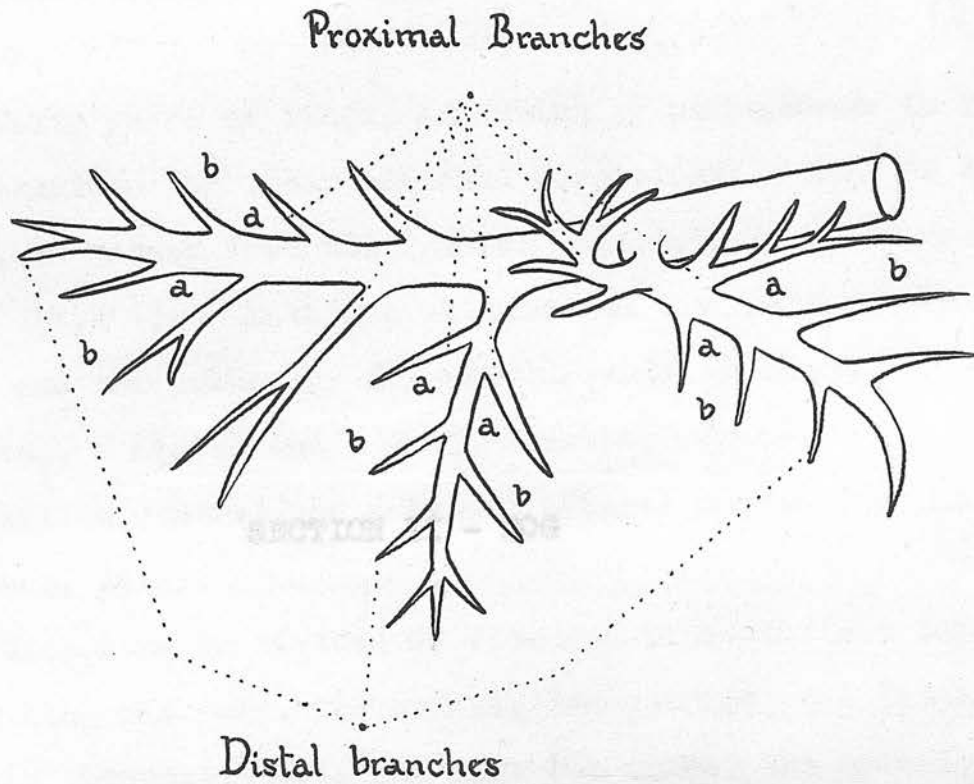
TERMS OF POSITION

The directional terms, "anterior", "posterior", "superior" and "inferior", used for the human anatomical descriptions, correspond to the set of terms, "ventral", "dorsal", "cephalic" and "caudal" used for the quadrupeds by the veterinary and comparative anatomists. A departure from this custom, in using a common terminology, necessitates altering the terminology for one or the other of these two types of mammals. Therefore, the use of both sets of terms has been maintained, the former for man and the latter for dog and other quadrupeds, even, at times, at the cost of brevity of expression. The terms, "lateral" and "medial", however, need no consideration.

It has been necessary to introduce the use of terms "proximal" and "distal" in relation to the branches of the bronchi and vessels to signify their positions in the lobe. Those which are near the hilar end are referred to as "proximal" and those which are away from it, i.e. near the farthest end of the lobe, as "distal" branches.

The terms, "proximal" and "distal", have also been used in order to refer to the parts of spaces between two adjacent branches of what will be described as the "lobar stem bronchus" (the central axial bronchus of a lobe from which branches arise in series). By proximal part of a space will be meant the part which is nearer the lobar stem bronchus, and by the distal part, the part which is nearer the peripheral border of the lobe, i.e., away from the lobar stem bronchus.

The above points are schematically illustrated in Fig. 10 .



a = Proximal parts of spaces
 b = Distal " " "

Fig. 10 . Schematic drawing to illustrate terms Proximal and Distal, as applied to bronchi and interbronchial spaces.

EXTERNAL MORPHOLOGY OF THE LUNGS OF THE DOG

(Figs. 11 to 17.)

A detailed general description of the external morphology of lungs is an essential preliminary to the study of intra-pulmonary anatomy.

Sixty pairs of lungs, including 37 pairs shown in Table were examined for their external morphology. Each of the two lungs, as viewed from the lateral aspect, is roughly triangular (Figs. 11A, 16A). Both are attached to the mediastinum by their roots and the pulmonary ligaments. Each presents three surfaces, a costal, a medial and a diaphragmatic, bounded by three borders, a dorsal, a ventral and a caudal ("basal border" - Bisson and Grossman, 1943).

SECTION II - DOG

Each lung is divided by fissures into distinct lobes. The right lung has four, the apical, the cardiac, the diaphragmatic and the intermediates. The left has three, the apical, the cardiac and the diaphragmatic. The right lung is bigger and heavier than the left lung. The apices of the lungs are formed by the apical lobes.

The Borders

The Dorsal Borders

The dorsal border of each lung is thick and rounded. Viewed from the dorsal aspect it is narrow cephalically where it commences at the apex. Caudally it broadens into a convex surface merging on either side imperceptibly into the costal and the medial surfaces. The cephalic half of the border is formed by the apical and the caudal half by the diaphragmatic lobe.

EXTERNAL MORPHOLOGY OF THE LUNGS OF THE DOG

(Figs. 11 to 17.)

A detailed general description of the external morphology of lungs in an essential preliminary to the study of intra-pulmonary anatomy.

Sixty pairs of lungs, including 37 pairs shown in Table were examined for their external morphology. Each of the two lungs, as viewed from the lateral aspect, is roughly triangular (Figs. 11A, 16A). Both are attached to the mediastinum by their roots and the pulmonary ligaments. Each presents three surfaces, a costal, a medial and a diaphragmatic, bounded by three borders, a dorsal, a ventral and a caudal ("basal border" - Sisson and Grossman, 1943).

Each lung is divided by fissures into distinct lobes. The right lung has four, the apical, the cardiac, the diaphragmatic and the intermediate. The left has three, the apical, the cardiac and the diaphragmatic. The right lung is bigger and heavier than the left lung. The apices of the lungs are formed by the apical lobes.

The Borders

The Dorsal Borders

The dorsal border of each lung is thick and rounded. Viewed from the dorsal aspect it is narrow cephalically where it commences at the apex. Caudally it broadens into a convex surface merging on either side imperceptibly into the costal and the medial surfaces. The cephalic half of the border is formed by the apical and the caudal half by the diaphragmatic lobe.

The Ventral Borders

The ventral border in each lung is thin. It extends from the apex to the ventral end of the cardiac lobe. About its middle it presents the cardiac notch which, in a collapsed or hardened lung, is usually bigger on the right side than on the left, but shows a wide variation in its size and depth. Cephalic to the notch, the margin is formed by the apical, and caudal to it by the cardiac lobe. The border occupies the costo-mediastinal recess. The right border seen from the ventral aspect is shaped like an inverted letter S (2), an appearance accentuated by the crossing of the right apical lobe to the left of the middle line (Fig. 50). The left border has a relatively straight course and the cardiac notch is usually shallow.

The Caudal Borders

Each caudal border encircles the diaphragmatic surface of the respective lung (Fig. 15). Its sharp lateral and dorsal part projects caudally into the costo-diaphragmatic sinus and is formed by the diaphragmatic and the cardiac lobes.

The medial parts of the right and the left caudal borders differ on the two sides.

On the right side it is formed by the caudal border of the diaphragmatic lobe dorsally, the sharp dorso-medial and the ventral borders of the intermediate lobe, and the thin medial border of the cardiac lobe.

On the left side it is formed by the medial boundary of the diaphragmatic surface of the diaphragmatic lobe, and a small part of the medial border of the cardiac lobe.

The left cardiac lobe, if small, does not appear on the diaphragmatic surface and then does not take part in the formation

of the caudal border.

Thus three lobes contribute to the formation of this border in the right lung and two in the left.

The Surfaces

The Costal Surface (Figs. 11 A, 16 A)

In each lung the costal surface is convex in conformity with the curvature of the thoracic wall. It is roughly triangular bounded by the dorsal, the ventral and the caudal borders of the lung. On each side it is formed by the apical, the cardiac and the diaphragmatic lobes.

The main features of this surface are the inter-lobar fissures, described separately. The intermediate lobe does not appear on this surface. The costal surface of the right lung is more extensive than that of the left lung.

The Diaphragmatic Surface (Fig. 15)

The diaphragmatic surface of the right lung is also more extensive than that of the left. Three lobes, the diaphragmatic, the intermediate and the cardiac, form the diaphragmatic surface of the right, and two lobes, the diaphragmatic and the cardiac, form this surface of the left lung. The left cardiac lobe forms only a small part of it which, as stated before, may not appear on this aspect of the lung.

The two surfaces are moulded upon the convex surface of the diaphragm and are, therefore, very obliquely placed. They are separated by the mediastinum, which can be seen from this aspect to consist only of two layers of pleura, between which run the left phrenic nerve, the accompanying vessels, the oesophagus and the aorta.

The Medial Surface (Figs. 12A, 12B, 12C, 17A, 17B)

The medial surface of each lung is smaller in extent than the costal, that of the right being more extensive than the left. Its dorsal part lies against the vertebral column and the larger ventral part against the mediastinum. The latter part, therefore, is the true mediastinal surface. The fissures of the right lung

In specimens hardened in situ this aspect of the lung bears well marked impressions produced by the mediastinal structures, indicated in the Figures. Being the biggest of the three, it has

The right lung is peculiar in possessing the intermediate lobe which juts medially through the "hiatus" bounded by the heart, the oesophagus, the caudal vena cava and the diaphragm, to occupy a recess of pleural cavity caudal to the heart (Fig. 15). Although all the four lobes of the right lung come into contact with the mediastinum, it is more convenient to describe its medial surface after detaching the intermediate lobe (Fig. 12B), describing the latter under a separate heading.

The medial surface of each lung (after detaching the intermediate lobe from the right lung) is formed by the apical, the cardiac and the diaphragmatic lobes. Over a triangular area approximately $1\frac{1}{2}$ to 2 inches by 1 to $1\frac{1}{2}$ inches, about the middle of this aspect, is situated the hilum. Ventro-cephalic to it is the cardiac concavity which in the right lung becomes much deeper when the intermediate lobe is in position. Details of various features, which will be referred to later, may be studied from the Figures.

The Fissures

Fissures may be complete or incomplete depending upon whether they penetrate completely or incompletely through the substance of the lung.

Three deep fissures on the right and two on the left^{side} were found to be constantly present. The fissures of the right lung are:-

1. A fissure which separates the diaphragmatic from the apical and the cardiac lobes. Being the biggest of the three, it has been called the "major" fissure.
2. A fissure separating the apical and the cardiac lobes. Being smaller, it has been termed the "minor" fissure.*
3. A "sagittal" fissure intervening between the diaphragmatic and the intermediate lobes (Fig. 15).

The two fissures of the left lung are:-

1. A fissure corresponding to the major fissure of the right lung.
2. A fissure corresponding to the minor fissure of the right lung.

The Major Fissure of the Right Lung

It commences a little caudal to the midpoint of the dorsal border of the lung and terminates at the caudal border of the

* Medlar (1947) has used the terms "major" and "lesser" to define the two main fissures of the human lungs. Here, while his term "major" has been retained, "lesser" has been replaced by the term "minor". The terms "oblique" and "horizontal", in current usage for the fissures of the human lungs, are not applicable to the two corresponding fissures in the dog, both of which are oblique.

costal surface approximately at the junction of its dorsal two-thirds and the ventral one-third. It is directed dorso-ventrally with a variable inclination caudally. In all lungs examined it was a complete fissure extending up to the hilum. It is, therefore, visible on the medial aspect. Its dorsal part separates the apical from the diaphragmatic lobe and the ventral part the cardiac lobe from the diaphragmatic lobe.

At this fissure the apical and the cardiac lobes overlap the diaphragmatic lobe, so that in the intact lung the fissure appears to be situated in a more cephalic plane when viewed from the medial aspect, as compared to the view presented by it on the costal aspect.

The Minor Fissure of the Right Lung

It separates the cardiac from the apical lobe. It extends from the apex of the cardiac notch, running dorso-caudally, to end by meeting the major fissure approximately at the junction of its dorsal two-fifths and the ventral three-fifths. In all the lungs it was a complete fissure extending up to the hilum. At this fissure the apical lobe overlaps the cardiac lobe and consequently its plane is such that it appears to be situated in a more dorso-cephalic plane when seen from the medial aspect.

Fissure Between the Intermediate and the Diaphragmatic Lobe - The "Sagittal" Fissure

It is a sagittal fissure slightly curved with its concavity towards the left. Laterally it is bounded by the right diaphragmatic and the cardiac lobes and medially by the intermediate lobe. A notch in the latter (Fig. 15) lodges the caudal vena cava and the right phrenic nerve. This notch divides the fissure into a dorsal and a ventral part. The latter part is

occupied by the pleural fold of the vena cava. This fissure was complete in all the lungs examined and extends up to the hilum. The corresponding parts of the opposing surfaces can be compared by referring to Figs. 12B and 13A.

The Major Fissure of the Left Lung

It corresponds in its position to the major fissure of the right lung. It extends from the middle of the dorsal border to end at the caudal border of the costal surface near its ventral end. It was found to be a complete fissure in all except one lung in which it was interrupted by a thick band of lung tissue traversing the middle of it (Fig. 9). The plane of the fissure is less oblique in the transverse direction as compared to the right lung. It is bounded by the diaphragmatic lobe and the fused apical and cardiac lobes.

The Minor Fissure of the Left Lung

This fissure separates the apical from the cardiac lobe only partially, so that in none of the lungs was it found to be a complete fissure. It commences at the cardiac notch as on the right side but penetrates into the lung substance to varying degrees of depth. By comparing the depth of the fissure with the thickness of the band of lung tissue connecting the two lobes, the degree of the completeness may be expressed in the following terms:-

	<u>No. of Lungs</u>	<u>Percentage</u>
Nearly complete	3	5%
More than half complete	44	73.33%
Half complete	12	20%
Less than half complete	1	1.66%
	—	—
	60	100%

At this fissure either of the two lobes may overlap the other (compare Figs. 9 and 16A). In 40 lungs the apical lobe overlapped the cardiac and in the remaining 20 the condition was reversed. The plane of the fissure varied according to which lobe overlapped the other.

Lastly it may be noted that the major and the minor fissures of both lungs are visible on the costal as well as on the medial surfaces. The two major fissures and the fissure between the intermediate and the diaphragmatic lobes are also visible on the diaphragmatic aspects of both the lungs.

THE MORPHOLOGY OF LOBES

The Right Apical Lobe (Figs. 11B, 12C)

It comprises the dorso-cephalic part of the lung and forms its apex. It is curved round the lateral and cephalic aspect of the heart. Viewed from the costal aspect it is roughly rectangular bounded by the dorsal border, the dorsal part of the major fissure, the minor fissure and the part of the ventral border of the lung cephalic to the cardiac notch. It overlaps the diaphragmatic lobe at the major, and the cardiac lobe at the minor fissure.

Its costal surface, a part of the general costal surface, is convex. The medial surface, less extensive than the costal, is applied to the mediastinum and the impressions borne by it are shown in Figs. 12A and 12B.

A notable feature on the medial surface is a curved blunt ridge which limits the impression produced by the heart from the area in contact with the thymus (Fig. 12A). This "ridge" fits into a depression in the mediastinum between the thymus and the pericardium. Its prominence varies from dog to dog, depending

upon the depth of the depression on the mediastinum. This ridge will be referred to simply as the "mediastinal crest" of the apical lobe in the subsequent account. This ridge corresponds in position to the "anterior crest" of the human right upper lobe described by Scannell and Boyden (1948) -(their Fig. 3Ca.)

In addition to the costal and medial surfaces there are two fissural surfaces, one opposing the diaphragmatic lobe, and the other opposing the cardiac lobe. They will be referred to as the fissural surfaces for the diaphragmatic lobe and for the cardiac lobe respectively.

These two surfaces are separated by a crest which may be termed the "interfissural crest" - a term suggested by Boyden and Scannell (1948) for a corresponding crest present in the right human upper lobe.

The lobe possesses the following borders:-

1. A "dorsal border" extending from the apex to the major fissure (part of the dorsal border of the lung).
2. A "ventral border" extending at first from the apex to the cardiac notch (in this part it is co-extensive with the ventral border of the lung) and then along the minor fissure up to the major fissure.
3. A "caudal" border which connects the ends of the previous two borders and forms the lateral boundary of the fissural surface for the diaphragmatic lobe.

The hilum of the lobe is situated on the medial surface in the angle between the dorsal part of the major and the minor fissure.

The Right Cardiac Lobe (Figs. 11B, 12C)

The cardiac lobe is triangular on cross section. It is

wedged into the space between the apical and the diaphragmatic lobes. It has a convex costal surface, a mediastinal deeply concave "cardiac" surface, a "fissural" surface opposing the apical lobe and a convexo-concave "caudal" surface, whose dorsal part bounds the major fissure and the ventral part (not marked off from the dorsal part) forms the diaphragmatic surface of the lobe.

Well marked borders, illustrated in the Figures, separate the four main surfaces. These borders are:-

1. A "cephalic" border, the ventral part of which is a part of the ventral border of the lung. Its dorsal part bounds the fissural surface for the apical lobe. This border is markedly convex cephalically.

2. A "caudal" border, the dorsal part of which borders upon the major fissure.

3. A "lateral" (oblique) border, bounding the fissural surface for the apical lobe laterally.

4. A "medial" border, extending from near the hilum to the ventral end of the lobe. This border is situated on a sharp crest between the cardiac and the caudal surfaces, and will be referred to as the "crest" of the cardiac lobe (the term "frenum" used by Boyden and Hamre (1949) for the corresponding ridge in the human lobe).

5. A border which may be called the "inter-fissural crest" separating the two fissural surfaces of this lobe, named thus because it abuts against the junction of the two fissures, as does the crest of the right apical lobe.

The hilum of the lobe is situated on the dorsal part of the cardiac surface in the angle between the major and the minor

fissures (Fig. 12B).

The Right Diaphragmatic Lobe (Figs. 11B, 12C)

It comprises part of the lung caudal to the major fissure. Triangular in appearance, it possesses an extensive convex costal surface, a less extensive medial surface, a concave diaphragmatic surface and a more or less flat fissural surface opposing the apical and the cardiac lobes at the major fissure.

The biggest feature on the medial surface is the area of contact with the intermediate lobe, which is divided by the impression for the caudal vena cava into a larger dorsal area and a smaller ventral area. These two parts should be considered as fissural surfaces bounding the fissure between the diaphragmatic lobe and the intermediate lobe, except that the ventral part is not in direct contact with the intermediate lobe due to the intervening vena caval fold of pleura.

It possesses the following borders:-

1. A thick rounded "dorsal" border part of the dorsal border of the lung.
2. A "caudal" border bounding the semilunar diaphragmatic surface.
3. A "lateral fissural" border forming the lateral boundary of the surface opposing the major fissure.
4. The "medial fissural" border forming the medial boundary of the same surface. Part of it is dorsal to the hilum, the remaining part ventral to it.

These borders are illustrated in Figs. 11B and 12C.

The hilum is situated on the medial surface and partly on the fissural surface, dividing the medial fissural border into two parts, mentioned above.

The Intermediate Lobe ("cardiac lobe" of Aeby; "azygos lobe" of Owen, quoted by Ewart)

(Figs. 12A, 13A, 13B, 14, 15)

Present only on the right side, it is situated medial to the diaphragmatic lobe accommodated in a special compartment, a recess of the pleural sac, lying between the heart and the diaphragm. The lobe is pyramidal in shape and possesses four surfaces separated by sharp borders.

The concave diaphragmatic surface, forming the base, is triangular. Two of its angles are pointed and have been labelled as the "ventral" and the "caudal" ends (Figs. 12A, 13A, 14). The third angle is the tongue shaped process which bounds the vena caval notch ventrally.

The right (lateral) surface (Fig. 13A) is applied to the diaphragmatic lobe and is marked by a deep groove for the caudal vena cava. The cephalic or cardiac surface, in an intact lung (Fig. 13B), completes the cardiac impression of the right lung and thus makes it deeper. The fourth surface may be termed the dorso-medial surface. It is concave dorsally where it is in contact with the oesophagus (Fig. 12A, 14). It is convex ventrally and is in contact with the two closely applied layers of the right and left mediastinal pleura which separate it from the left diaphragmatic lobe.

The terminology suggested for its borders is as follows:-

1. A sharp "dorsal" border separating the dorso-medial surface from the diaphragmatic surface. (A more appropriate name would be a "dorso-medial" border.)
2. A sharp "ventral" border separating the cardiac surface from the diaphragmatic surface.

3. A sharp "cephalic" border separating the cardiac surface from the dorso-medial surface.

Two other borders have been left unnamed and labelled as such in Fig. 13A, as it has not been found necessary to name them.

The hilum of the lobe is situated at its apex where the lateral, the dorso-medial and ^{the} cardiac surfaces meet. The apex is marked, dorsal to the hilum, by a groove which lodges the vein draining the right diaphragmatic lobe.

The Left Apical and the Left Cardiac Lobes (Figs. 16B, 17B)

These two lobes, being partially fused due to the incomplete minor fissure, are described together for convenience. Either of the two lobes may overlap the other at the minor fissure as stated before. Together they possess a convex costal surface, a medial surface and a fissural surface. These surfaces are separated by borders which are:-

1. A thick "dorsal" border, part of the dorsal border of the lung.

2. A thin "ventral" border which corresponds to the ventral border of the lung.

3. A "lateral fissural" border which bounds the fissural surface for the diaphragmatic lobe laterally.

4. A "medial fissural" border which bounds the fissural surface for the diaphragmatic lobe medially.

These borders are indicated in the Figures.

When the apical lobe overlaps the cardiac lobe, the costal surface of the former is larger and the medial surface smaller, and the costal surface of the latter is small and the medial surface large. The conditions are reversed when the cardiac lobe overlaps the apical lobe.

The fissural surface for the diaphragmatic lobe remains uninterrupted as the minor fissure stops short of the major fissure. The extreme ventral part of this surface (on the cardiac) lobe comes into contact with the diaphragm, but not to the same extent as on the right side (Fig. 15), and sometimes it may not do so. On the medial aspect the most prominent feature is the cardiac impression borne almost entirely by the cardiac lobe, but ^{it} extends across both the minor and the major fissures to produce impressions upon the apical and on the diaphragmatic lobes.

The two lobes share a single hilum situated opposite the bridge of lung parenchyma connecting the two lobes.

The apical lobe forms the apex of the lung which is more pointed than the right apex. In contrast to the apical lobe of the right side, the left apical lobe is triangular, smaller and thinner, but resembles it in possessing a costal, a medial and two fissural surfaces, one for the minor and the other for the major fissure.

The cardiac lobe also resembles the corresponding lobe on the right side in possessing a costal, a medial and two fissural surfaces.

A comparison of the borders of these two lobes with those of the corresponding lobes of the right side is complicated by the fusion of the lobes on the left side.

The lateral fissural border of the left apical and cardiac lobes corresponds to the caudal borders of the two corresponding right lobes. The medial border of the cardiac lobe is represented on the left side by the lower part of the medial fissural border. The cephalic border of the left cardiac lobe

(Fig. 16B) is formed in its ventral part, as on the right side, by the caudal part of the ventral border of the lung.

The ventral border of the left apical lobe (Fig. 17B) in its cephalic part is co-extensive with the cephalic part of the ventral border of the lung. The relationship of each of the two borders, the ventral of the apical and the cephalic of the cardiac, would depend upon which of these two lobes overlaps the other.

The Left Diaphragmatic Lobe

It resembles the corresponding lobe of the right side in all respects, but for its relations and features on the medial aspect, which may be compared by reference to Figs. 12B and 17A.

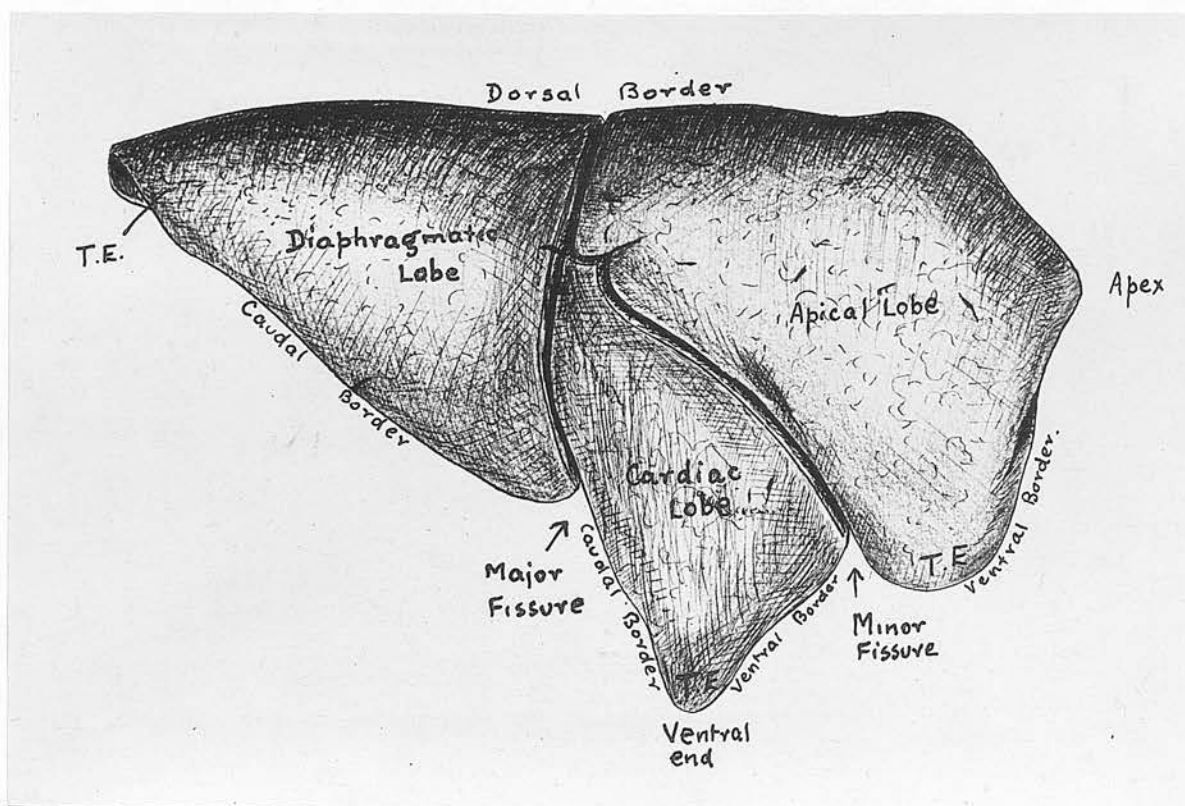


Fig. 11 A. — Drawing of Costal View of Right Lung of Dog. (Specimen M15)

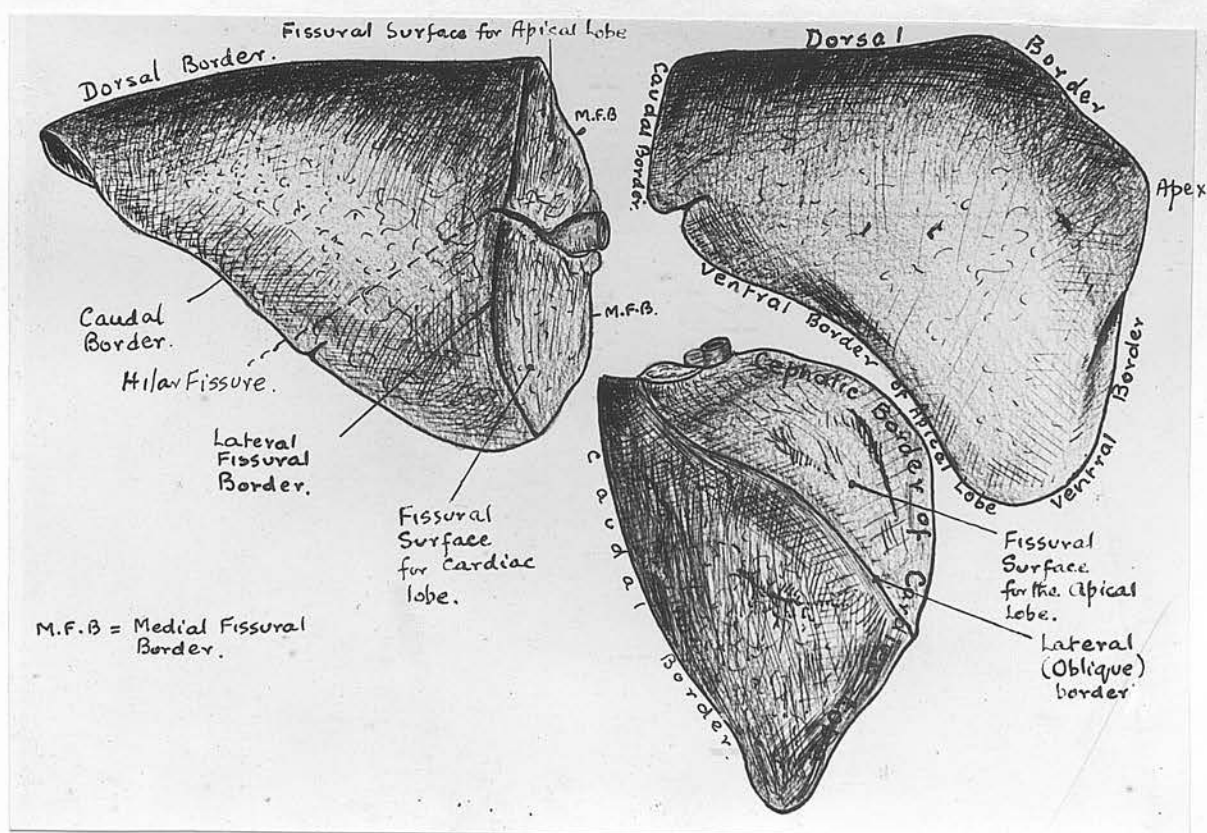


Fig. 11 B. — Drawing of Costal View of Right Lung of Dog (Specimen M15) Lobes Separated.

Fig. 12 A, B, C.

1. Groove for trunk of vertebral, cervical and dorsal veins.
2. Groove for vena azygos.
3. Groove for cranial vena cava.
4. Tracheal impression and right vagus nerve.
5. Groove for internal thoracic vessels.
6. Impression produced by right stem bronchus after giving off bronchus to apical lobe.
7. Thymic impression.
8. Groove for caudal vena cava.
9. Area for oesophagus.
10. Area in contact with intermediate lobe.
- 10a. Area in contact with vena caval fold of pleura, intervening between intermediate and diaphragmatic lobes.
11. Impression of phrenic nerve.
12. Ventral part of caudal surface of cardiac lobe in contact with diaphragm.
13. Diaphragmatic surface of diaphragmatic lobe.
14. Area in contact with subclavian artery.
15. Paravertebral surface.
16. Mediastinal crest.
17. Cephalic artery.
18. Caudal artery.
19. Lobar vein of apical lobe.
20. Bronchus - right apical lobe.
21. Hilum - cardiac lobe containing lobar artery (blue), lobar bronchus (yellow) and lobar vein (red).
22. Bronchus - right diaphragmatic lobe.
23. Vein - right diaphragmatic lobe.
24. Artery - right diaphragmatic lobe.
25. Artery (blue), bronchus (yellow) and vein (red) of the intermediate lobe.

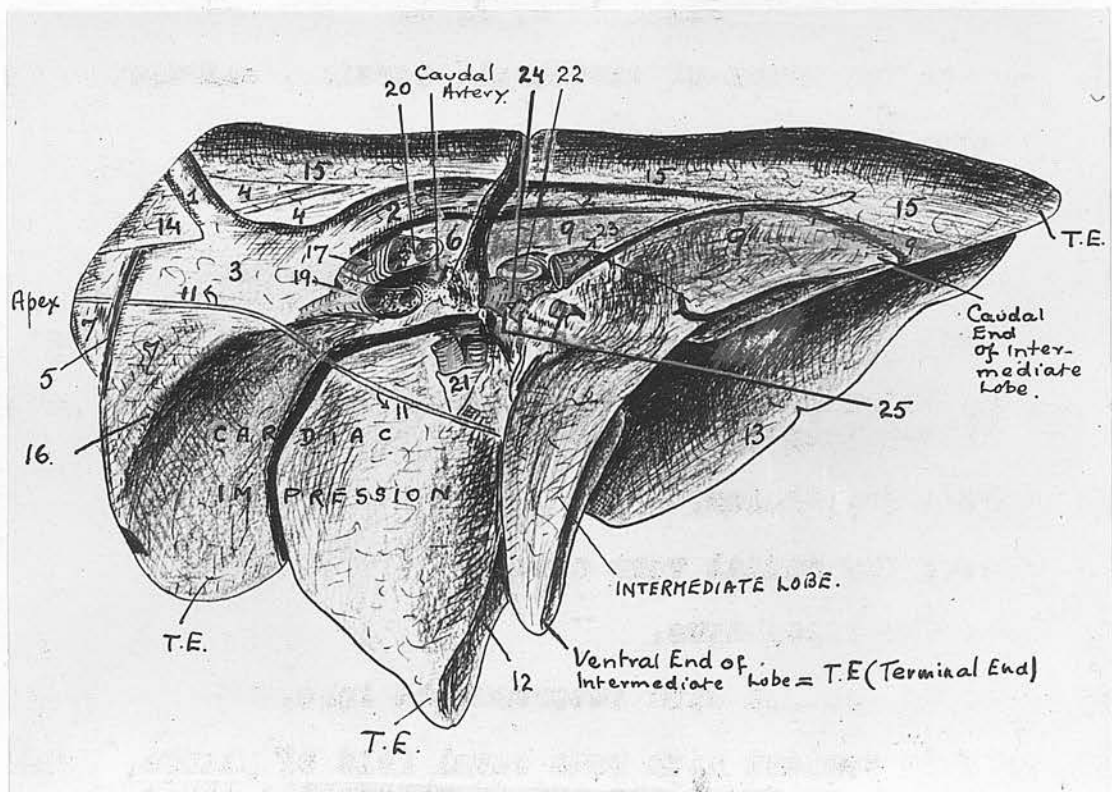


Fig. 12 A.- Drawing of Medial View of Right Lung of Dog (Specimen M15)

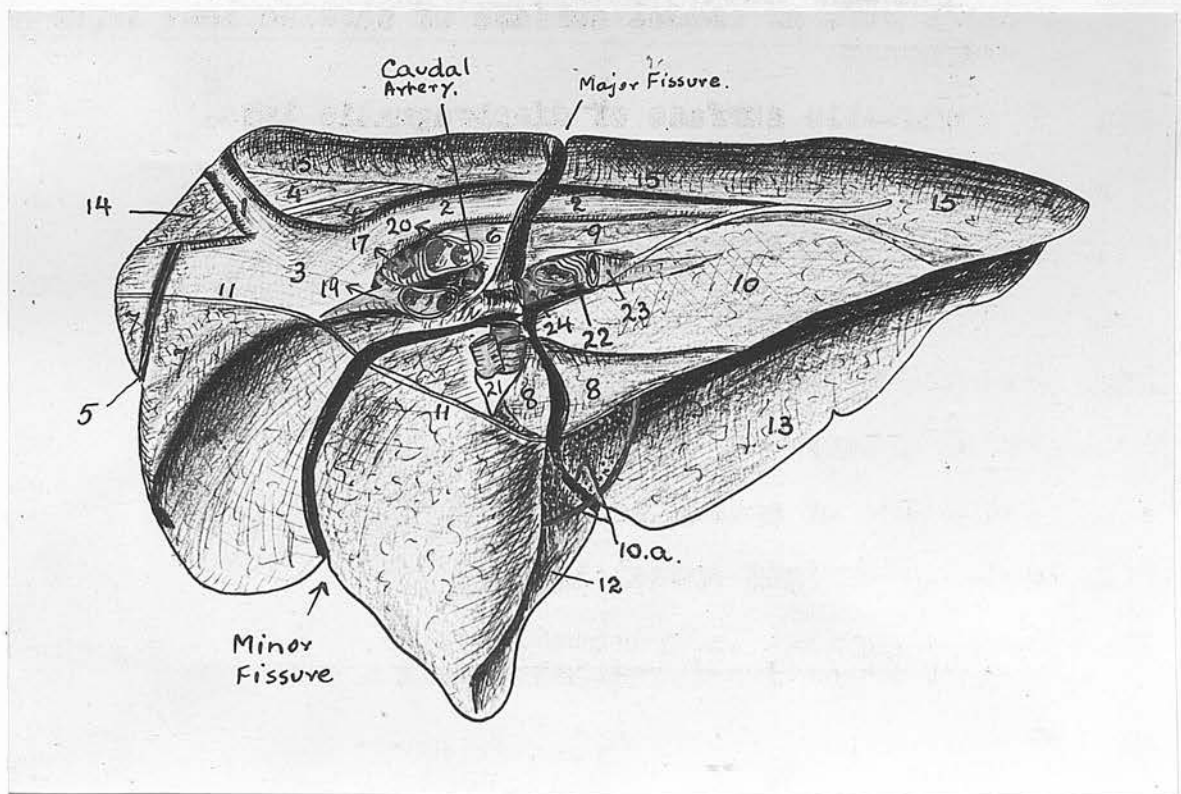


Fig. 12 B.- Drawing of Medial View of Right Lung of Dog (Specimen M15)
Intermediate Lobe removed.

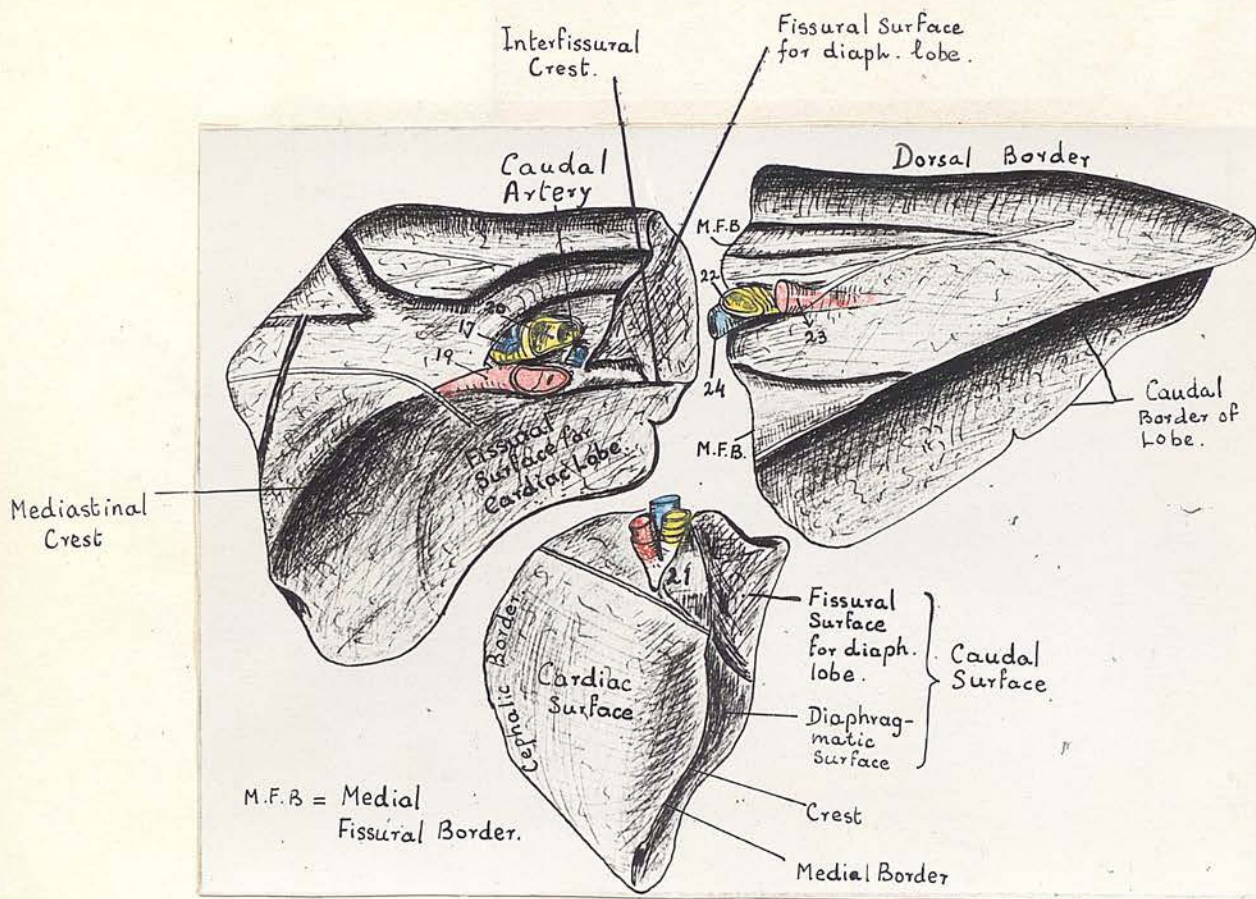
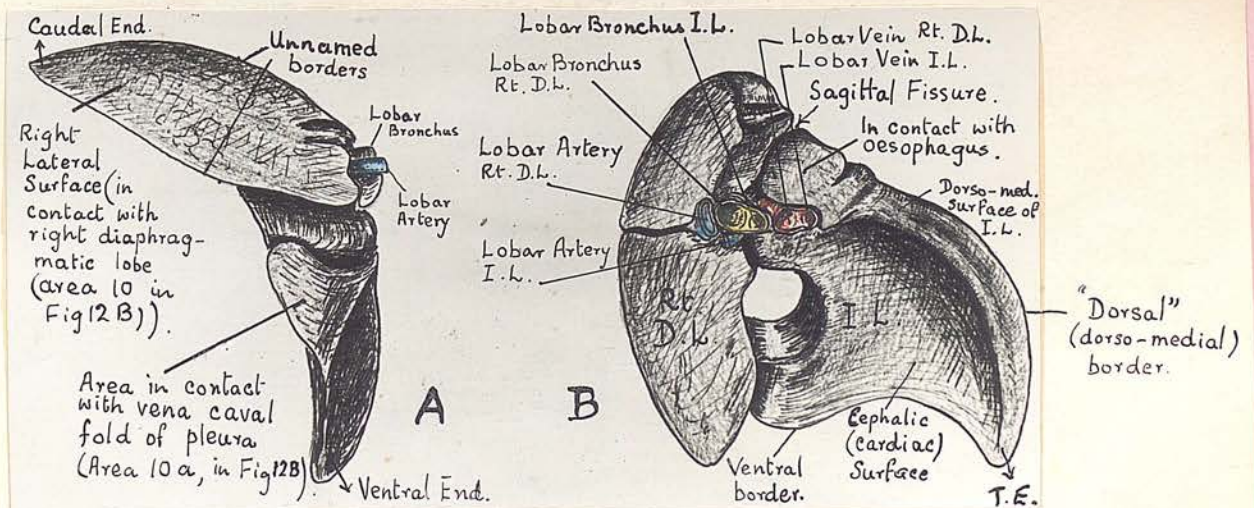
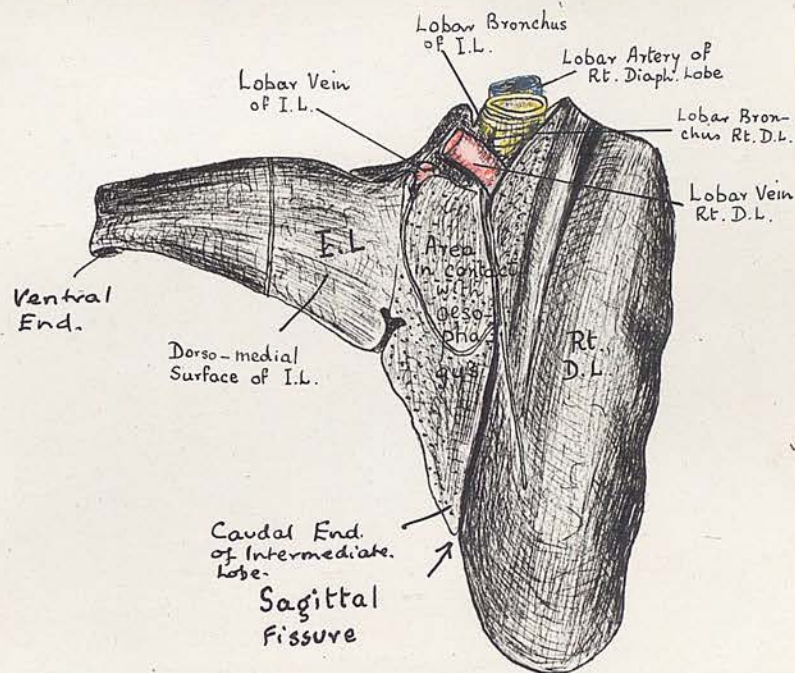


Fig. 12 C. — Drawing of Medial View of Right Lung of Dog (Specimen M 15). Intermediate Lobe removed. Lobes separated.



I.L. = Intermediate Lobe.
Rt D.L. = Right Diaphragmatic Lobe.

Fig. 13 . — A, Drawing of Right Lateral View of Intermediate Lobe. B, Drawing of Cephalic View of the Intact Right Diaphragmatic Lobe and Intermediate Lobe of Dog.
(Specimen M 15)



I.L. = Intermediate Lobe.
Rt. D.L. = Right Diaph. Lobe.

Fig. 14. — Drawing of the Dorso-medial View of the Intact Right Diaphragmatic and Intermediate Lobes (Specimen M15).

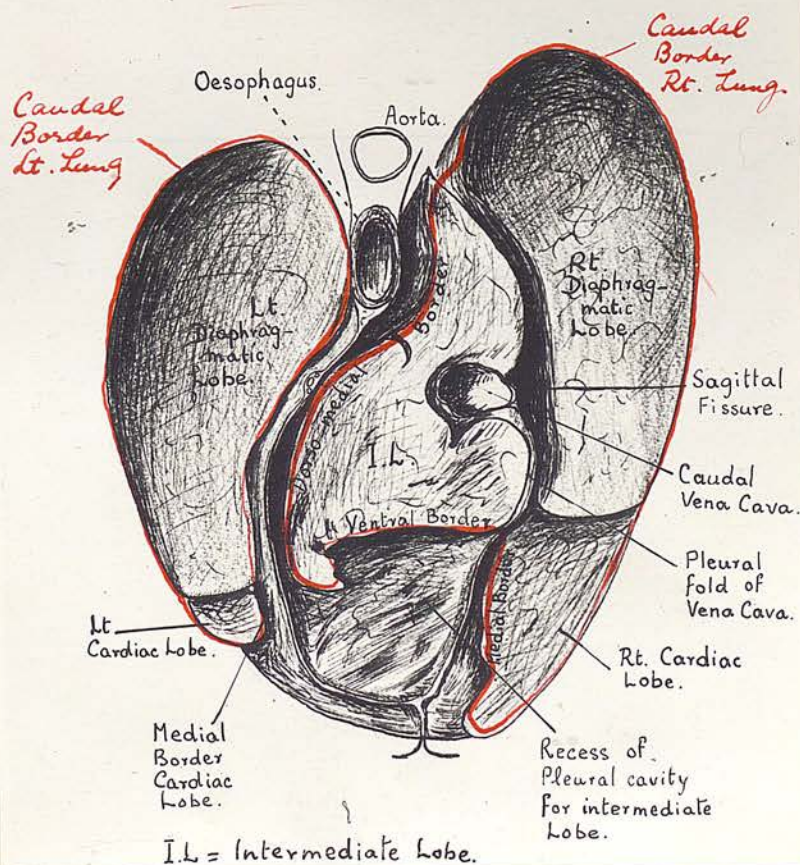


Fig. 15. — Drawing of the Diaphragmatic View of both Lungs of Dog. (Specimen M15).

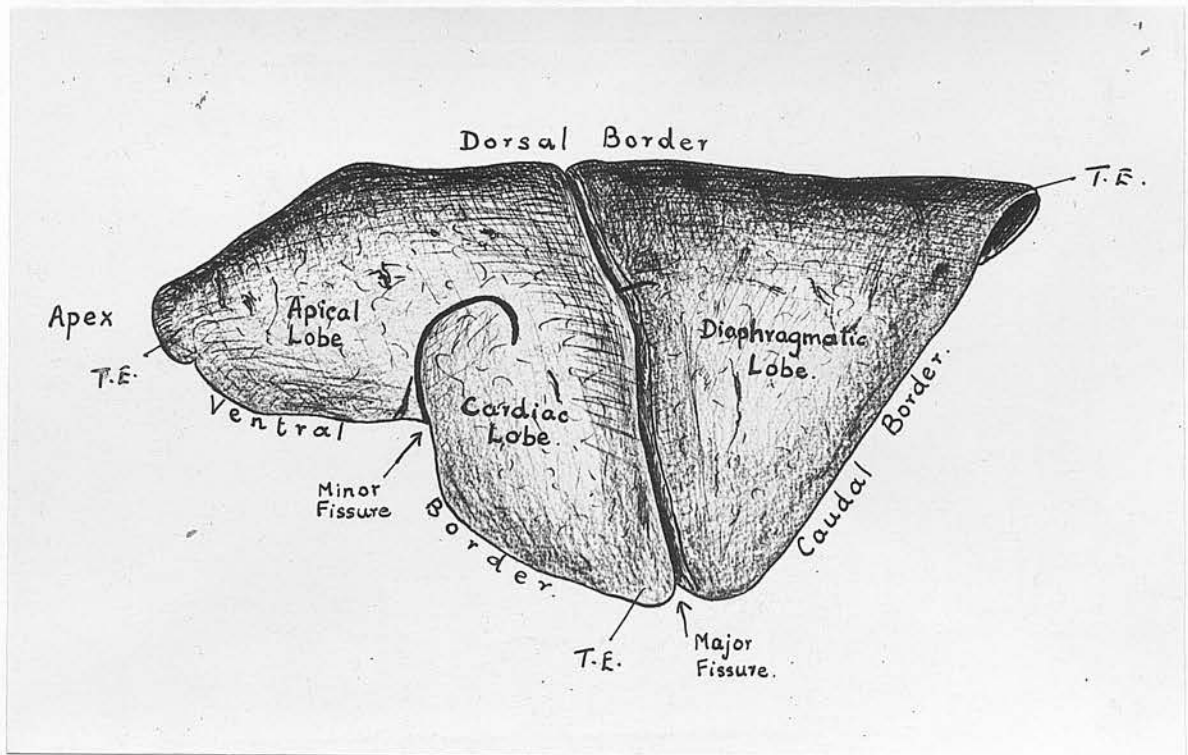


Fig. 16 A.— Drawing of Costal View of Left Lung of Dog (Specimen M15)

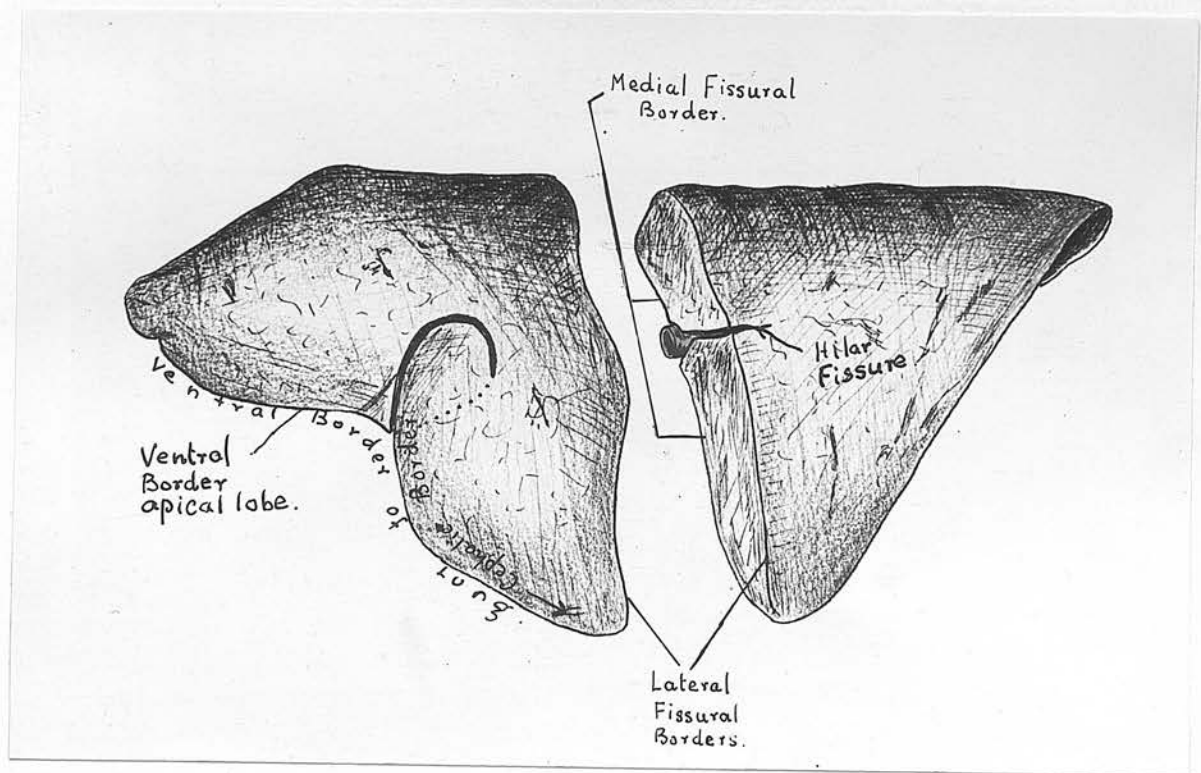


Fig. 16 B.— Drawing of Costal View of Left Lung of Dog (specimen M15).
Lobes separated.

Fig. 17 , A & B.

1. Groove for internal thoracic vessels.
2. Thymic impression.
3. Paravertebral surface.
4. Area for oesophagus.
5. Groove for subclavian artery.
6. Groove for brachio-cephalic artery.
7. Vagal impression.
8. Impression of phrenic nerve.
9. Groove for aorta.
10. Impression for intermediate lobe separated by two layers of mediastinal pleura.
11. Diaphragmatic surface.
12. Lobar vein - Left Apical Lobe.
13. Lobar artery - Left Apical Lobe.
14. Lobar artery - Left Cardiac Lobe.
15. Lobar vein of Left Cardiac Lobe.
16. Common bronchus - Left Apical and Cardiac Lobes.
17. Lobar artery - Left Diaphragmatic Lobe.
18. Lobar bronchus - Left Diaphragmatic Lobe.
19. Lobar vein - Left Diaphragmatic Lobe.

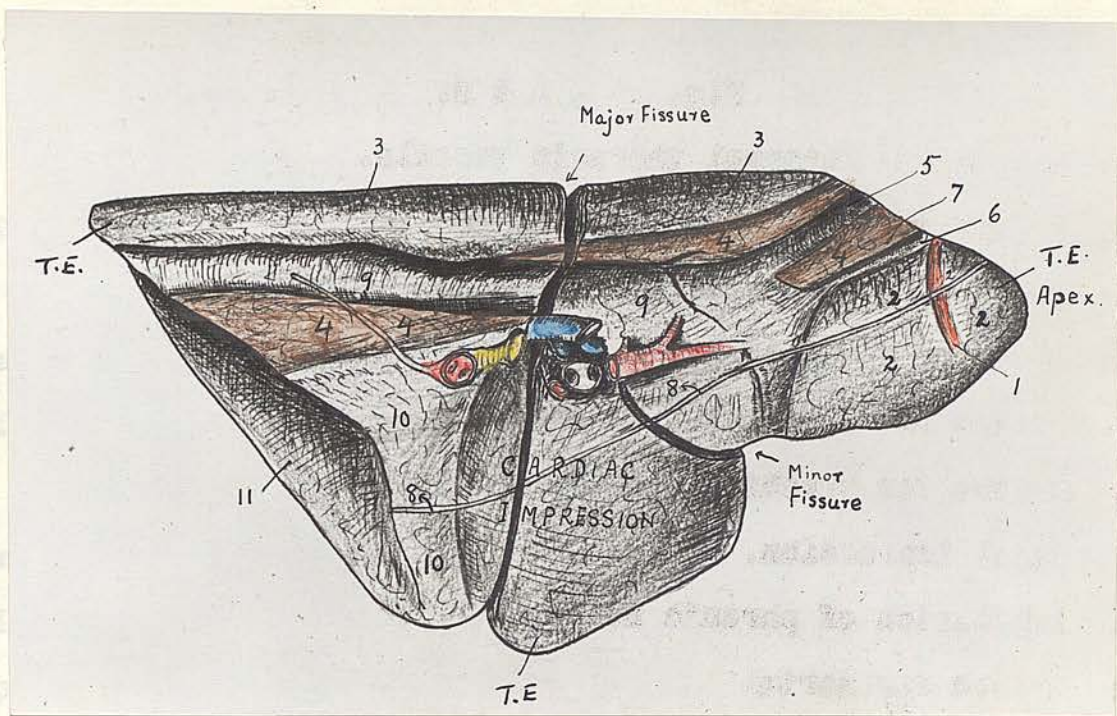


Fig. 17 A.— Drawing of Medial View of Left Lung of Dog (Specimen M 15).

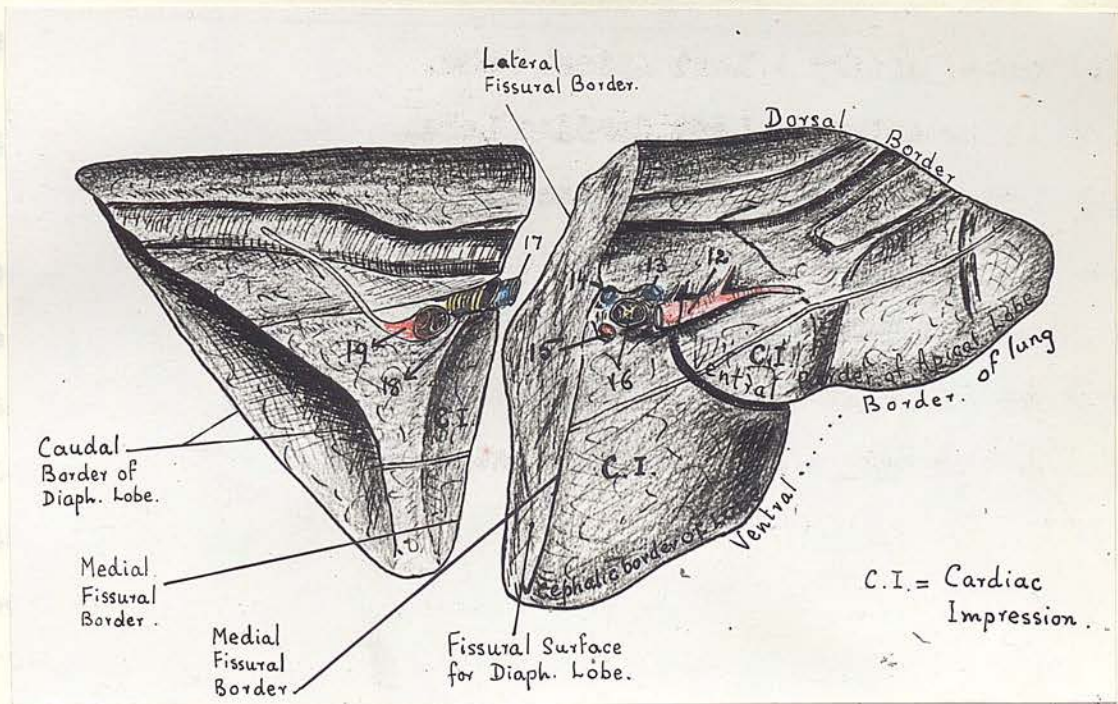


Fig. 17 B.— Drawing of Medial View of Left Lung of Dog.
(Specimen M 15). Lobes separated.

THE HILA OF INDIVIDUAL LOBES (Figs. 11B; 12A, B+C; 13A+B; 16B; 17B)

The study of the hilar regions was made on 18 pairs of lungs.

The hilum of the right lung is divided into four separate parts by the three interlobar fissures. Each part is the hilum of its respective lobe.

That of the left lung is divided by the major fissure into two parts only, the caudal portion being the hilum of the diaphragmatic, and the cephalic portion, the common hilum of the apical and the cardiac lobes, this being the result of failure of the minor fissure to extend right up to the hilum.

Thus there are four lobar hila in the right and two in the left lung. Each of the six lobar hila and the arrangement of the constituent structures is given below.

The Right Apical Lobe

The hilum of the right apical lobe is situated on its medial aspect in the angle between the major and the minor fissures. The constituents consist of a lobar bronchus, a lobar vein and 1 to 3 lobar arteries arising independently from the pulmonary artery. The bronchus occupies a more or less central position with the vein lying ventro-cephalic or ventral to it. Fourteen lobes were supplied by 2, two lobes by 1, and the remaining two by 3 arteries each. The details of these arteries and their terminology will be discussed later in the description of arteries of the right apical lobe.

The Right Cardiac Lobe

The hilum of the right cardiac lobe is situated on the dorsal

most part of the cardiac impression. One bronchus, one artery and one vein were noted in the hilum of each of the lobes examined. The bronchus occupies an intermediate position with the artery on its dorso-lateral (in some cases slightly cephalic) and the vein on its ventro-medial and slightly cephalic aspect.

The Right Diaphragmatic Lobe

The hilum of the right diaphragmatic lobe is situated on the medial aspect opposite the minor fissure (Fig. 12B), the bronchus occupying an intermediate position, with the artery on its lateral and the vein on its medial side.

The Intermediate Lobe

The hilum of the intermediate lobe is situated at the apex of the lobe. It contains a bronchus, occupying an intermediate position, an artery on its ventro-lateral and a vein on its medial aspect. In two lobes the single vein was replaced by two separate veins.

The Left Apical and the ^{Left} Cardiac Lobe

The common hilum of these two lobes is situated between the blind end of the minor fissure and the major fissure (Fig. 17B). One common bronchus for both lobes, two veins, one from each of the two lobes and ^{one three} / to / arteries were found in each hilum. The bronchus occupies an intermediate position with the arteries dorsal, and veins ventral to it. In the majority of the lobes (14 out of 18) two arteries were found, one for the apical lobe lying dorso-cephalic, and the other for the cardiac lobe, lying dorso-caudal to the common bronchus (as in Fig. 17B). In 3 specimens three arteries were recognised, the third artery lying

between the other two, dorsal to the bronchus as an additional artery to the apical lobe. In one specimen a single artery, lying dorsal to the bronchus, supplied both lobes.

The Left Diaphragmatic Lobe

The hilum of this lobe is situated, as on the right side, in an identical position. The number and the relative positions of the structures are the same as on the right side, except that the vein emerges ventro-medial to the bronchus, this difference being due to the fact that on the right side the vein has to pass dorsal to the bronchus of the intermediate lobe (Fig. 14).

The findings, in 18 pairs of lungs, given above, are summarised in Table 3.

Table 3.

Analysis of the Constituents of the Lobar Hila
in 18 Pairs of Lungs

Lobes	Number of ARTERIES per Lobe	Number of BRONCHI per Lobe	Number of VEINS per Lobe
Right Apical	1 in 2 lobes 2 in 14 " 3 in 2 "	1	1
Right Cardiac	1	1	1
Right Diaphragmatic	1	1	1
Intermediate	1	1	1 in 16 lobes 2 " 2 "
Left Apical and Cardiac Lobes	1 in 1 specimen 2 " 14 specimens 3 " 3 "	1	2 for each pair of lobes
Left Diaphragmatic	1	1	1

THE TRACHEA AND THE MAIN BRONCHI

The trachea is on the average 18 mm. long (measured in 10 dogs). It bifurcates into two main branches which enter the cephalic part of the left atrium (Fig. 36).

Each of the two main bronchi, making an angle of less than a right angle, proceeds caudally and laterally from the bifurcation of the trachea to the hilum of its respective lung.

The right bronchus, having given off branches to the apical and the cardiac lobes, continues to supply the intermediate and the diaphragmatic lobes. The left bronchus gives off a single (common) bronchus to the left apical and the cardiac lobes and then continues to supply the left diaphragmatic lobe.

In each lung the **THE BRONCHIAL TREE** continues through the respective diaphragmatic lobe, giving off branches from its sides, to terminate at the most caudal end of the lung (Fig. 24).

In both main bronchi maintain their individuality as axial stems, from their origin to their terminations. The term "stem bronchus" of Levy, for each of them, is found to be very apt.

Each stem bronchus describes a curve, the concavity of which is directed dorsally and medially. Near its origin it exhibits a ventral bend and near its termination is directed slightly dorsally. The caliber of each bronchus gradually decreases from its origin to its termination.

On the right side the branches to the apical lobe originate from the cephalic and lateral, the branches to the cardiac lobe from the ventral, and the branches to the intermediate lobe from the medial and ventral aspects of the main bronchus. On the left side the common branches to the apical and the cardiac

THE TRACHEA AND THE MAIN BRONCHI slightly ventral

The trachea is on the average 18 cms. long (measured in 10 dogs). It bifurcates into two main bronchi dorsal to the cephalic part of the left atrium (Fig. 36 A + B).

Each of the two main bronchi, making an angle of less than a right angle, proceeds caudally and laterally from the bifurcation of the trachea to the hilum of its respective lung.

The right bronchus, having given off branches to the apical and the cardiac lobes, continues to supply the intermediate and the diaphragmatic lobes. The left bronchus gives off a single (common) bronchus to the left apical and the cardiac lobes and then continues to supply the left diaphragmatic lobe.

In each lung the main bronchus is continued through the respective diaphragmatic lobe, giving off branches from its sides, to terminate at the most caudal end of the lung (Fig. 26A).

As both main bronchi maintain their individuality as axial stems, from their origins to their terminations, the term "stem bronchus" of Aeby, for each of them, is found to be very apt.

Each stem bronchus describes a curve, the concavity of which is directed dorsally and medially. Near its origin it exhibits a ventral trend and near the termination is directed slightly dorsally. The calibre of each diminishes gradually from the origin to the termination.

On the right side the bronchus to the apical lobe originates from the cephalic and lateral, the bronchus to the cardiac lobe from the ventral, and the bronchus to the intermediate lobe from the medial and ventral aspects of the right main bronchus. On the left side the common bronchus to the apical and the cardiac

lobes originates from the cephalic, lateral and slightly ventral aspect of the left main bronchus. (Fig. 18).

Each lobe is served by a single bronchus. It traverses the lobe as an axial line extending from the hilum to the end of the lobe where it terminates. This point of termination in each of the seven lobes is almost constant. A few exceptions will be mentioned later. These ends of the lobes have been called the "terminal ends", marked T.E. in Figs. 11A, 12A, 13B, 16A, 17A.

The main series of branches were found to arise from the opposite aspects of the "axial" bronchus of each lobe (Figs. 19, 20, 21A, 40, 41, 42, 43, 44, 45). The term "lobar stem branches", to distinguish it from the "main branches" of Ashy, is suggested and used in the accompanying account.

Between the origins of the two main series, the lobar stem bronchus bears irregular small branches which are not arranged in any well marked series. These have been called "secondary" bronchi.

Generally, the origins of the two main series of bronches are in a descending order of size from the proximal hilum end to the distal, peripheral end of the lobe. The distal branches in each series appear to be of the same size or smaller than those of the proximal series.

* The term "axial bronchus" has been used by Ashy (1937) and by Hayward and Ashy (1938) in relation to the lungs of other mammals.

† Originally the term "secondary bronchi" was used by Ashy in relation to the secondary bronchi of the lungs of mammals only. Later, this term was also applied to the secondary bronchi of lobar stem bronchi.

GENERAL OBSERVATIONS ON THE BRONCHIAL PATTERNS
OF ALL SEVEN LOBES

Each lobe is served by a single bronchus. It traverses the lobe as an axial stem extending from the hilum to the end of the lobe where it terminates. This point of termination in each of the seven lobes is almost constant. A few exceptions will be mentioned later. These ends of the lobes have been called the "terminal ends", marked T.E. in Figs. 11A, 12A, 13B, 16A, 17A.

Two main series of branches were found to arise from the opposite aspects of the "axial" bronchus^{*} of each lobe (Figs. 19, 20, 21A, 40, 41, 42, 43, 44, 45, 46). The term "lobar stem bronchus", to distinguish it from the "stem-bronchus" of Aeby, is suggested and used in the subsequent account.

Between the origins of the two main series, the lobar stem bronchus bears irregular small branches which are not arranged in any well marked series. These have been called "accessory" bronchi.[‡]

Generally, the members of the two main series of branches are in a descending order of size from the proximal (hilar) end to the distal (terminal) end of the lobe. The distal branches are in each series/almost equal in size or are even smaller than some of the accessory bronchi.

* The term "axial bronchus" has been used by Reid (1950) and by Hayward and Reid (1952) in relation to the segmental bronchus.

‡ Originally the term "accessory bronchi" (Nebenbronchen) was used by Aeby in relation to the accessory branches of stem bronchi only. Here, they are used in relation to the branches of lobar stem bronchi.

Each series of branches is directed towards a definite border of the respective lobe. These borders are illustrated in Figs. 40, 41, 42, 43, 44, 45, 46.

A "normally" developed member of a series extends from its origin right up to its respective border. There are examples, however, in almost all the series, of branches which have become overdeveloped, usually at the expense of the neighbouring branches which may remain underdeveloped or even rudimentary, depending upon the degree of overgrowth. An underdeveloped branch fails to reach the border of the lobe with the result that the areas of supply of the preceding and the succeeding branch or branches in the series meet around the area of supply of this underdeveloped branch.

The following are some of the examples of abnormally developed bronchi in each of the seven lobes:-*

Right Apical Lobe

Fig. 64 A - Bronchus v_4 is underdeveloped and bronchus V_3 appears overdeveloped.

Fig. 24 A - Bronchus d_2 is underdeveloped. Bronchi D_1 and D_3 are both overdeveloped and the areas supplied by them meet round the area supplied by bronchus d_2 .

Right Cardiac Lobe

Specimen E50 - Bronchus P_4 and P_5 are both underdeveloped.

Right Diaphragmatic Lobe

Fig. 22 - Bronchus v_2 is underdeveloped.

Intermediate Lobe

Fig. 21 A - Bronchus v_2 is underdeveloped and bronchi V_1 and V_3 are overdeveloped. In the same specimen bronchi v_4 and v_5 are also underdeveloped.

* The terminology used for the bronchi in these examples is explained later under Nomenclature (page 80).

Left Apical Lobe

Fig. 24B - Bronchus d_2 is under-developed.

Left Cardiac Lobe

Fig. 24B - Bronchi a_2 and a_3 are under-developed and bronchus A_1 is over-developed.

Left Diaphragmatic Lobe

Fig. 23 - Bronchi v_3 and v_4 are under-developed.

There are thus three "categories" of branches:-

- (1) Normal sized branches
- (2) Over-developed branches
- (3) Under-developed or rudimentary branches.

The total number of branches arising from the lobar stem bronchus and the number of branches in each series varies from lobe to lobe and from one lung to the other.

The order in which the branches originate from the lobar stem bronchus, as will be seen later, also showed variations.

In the majority of lobes the lobar stem bronchus was traceable up to or almost up to the extreme terminal end of the respective lobe. Some examples of this may be seen in Fig. 64A for the right apical lobe, in Fig. 25B for the left apical lobe, in Fig. 24B for the left cardiac lobe and in Fig. 26A for both the diaphragmatic lobes.

In the remaining few lobes it was found to undergo a bifurcation before reaching the terminal end of the lobe. Examples of this may be seen in Figs. 19 and 26B for the right apical lobe, in Fig. 24B for the left apical lobe, in Fig. 25B for the left cardiac lobe and in Fig. 21A for the intermediate lobe.

The examples given in the preceding paragraph are of those lobes in which bifurcation took place at an exceptionally early

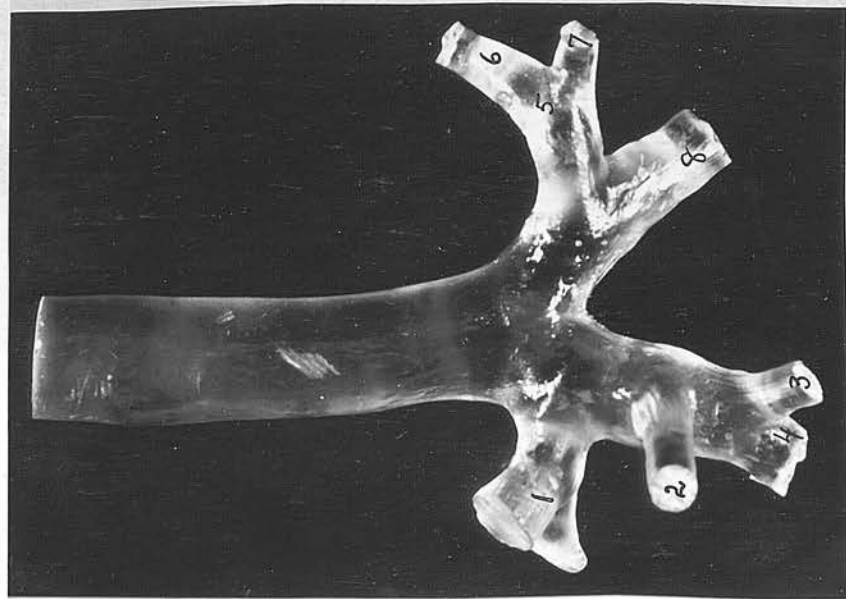
stage of the course of the respective lobar stem bronchus.

There were other examples, to be pointed out later, in which the bifurcation of the lobar stem bronchus took place at variable distances but very near the terminal ends, roughly speaking in the distal one-fourth or one-fifth of the lobe.

The lobar stem bronchus was considered to bifurcate when neither the direction nor the thickness of the bronchus, in the dissected specimen or in the cast, helped to determine which of the two products of division was the continuation.

Before proceeding any further it is necessary to consider the nomenclature which is discussed next.





A



B

Fig. 18 . Marco Resin cast of the Trachea and Main Bronchi to show the arrangement of Lobar Bronchi. A, Ventral View. B, Dorsal View.

1. Bronchus, right apical lobe. 2. Bronchus, right cardiac lobe.
 3. Bronchus, intermediate lobe. 4. Bronchus, right diaphragmatic lobe.
 5. Common bronchus, left apical and cardiac lobes. 6. Bronchus, left apical lobe.
 7. Bronchus, left cardiac lobe. 8. Bronchus, left diaphragmatic lobe.

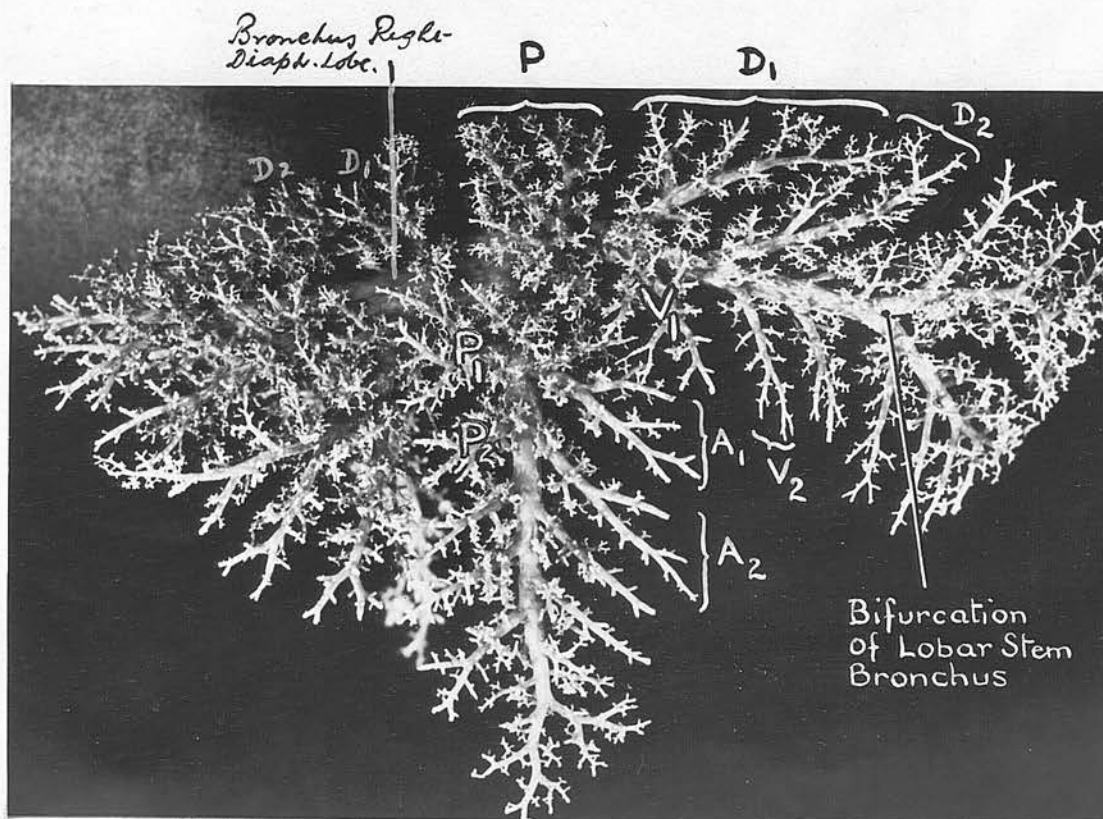


Fig. 19 . Celloidin cast of the Bronchial Tree of Right Lung of Dog (Specimen E53).

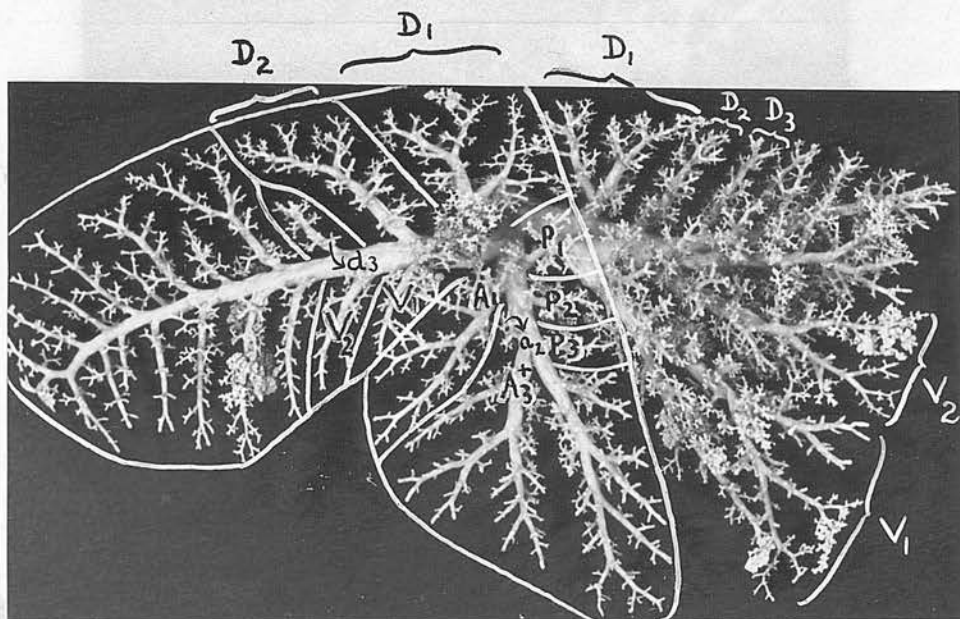
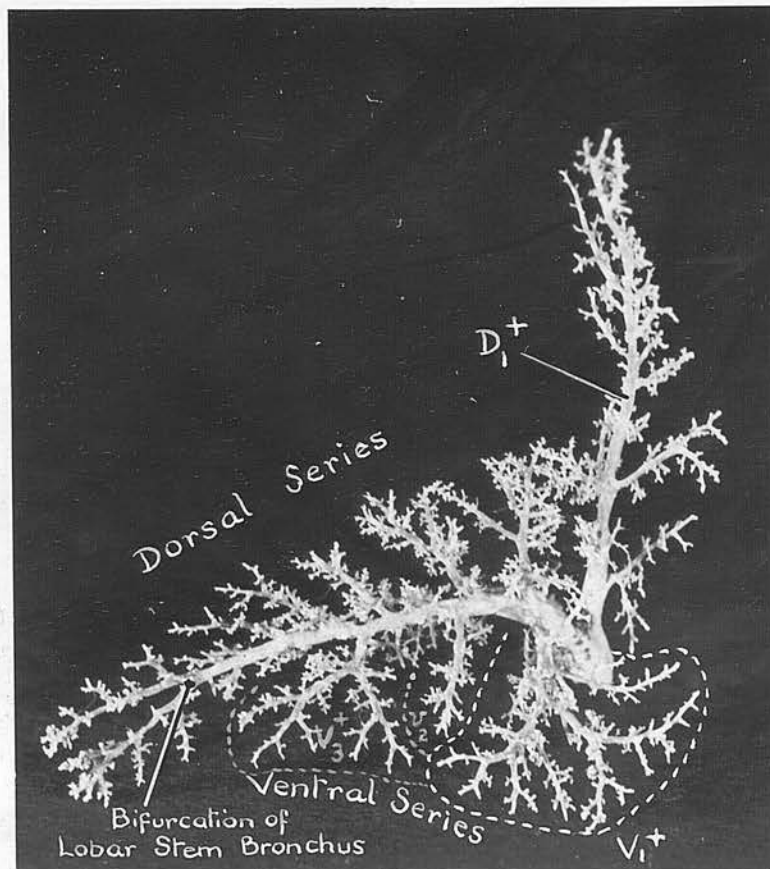


Fig. 20 . Celloidin cast of the Bronchial Tree
of Left Lung of Dog (Specimen E53).



A. Caudo-ventral View



B. Dorso-medial View

Fig. 21 , A & B. Celloidin cast of the Bronchi of the Intermediate Lobe of Dog's Lung. (Specimen E33)

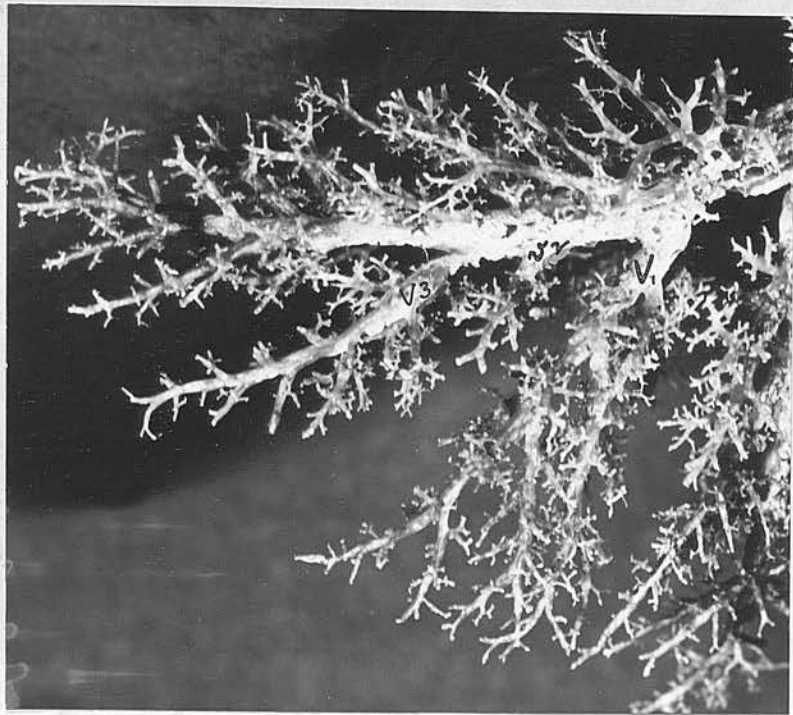


Fig. 22 . Celloidin cast of the bronchi of Right Diaphragmatic Lobe of Dog's Lung (Specimen E29).

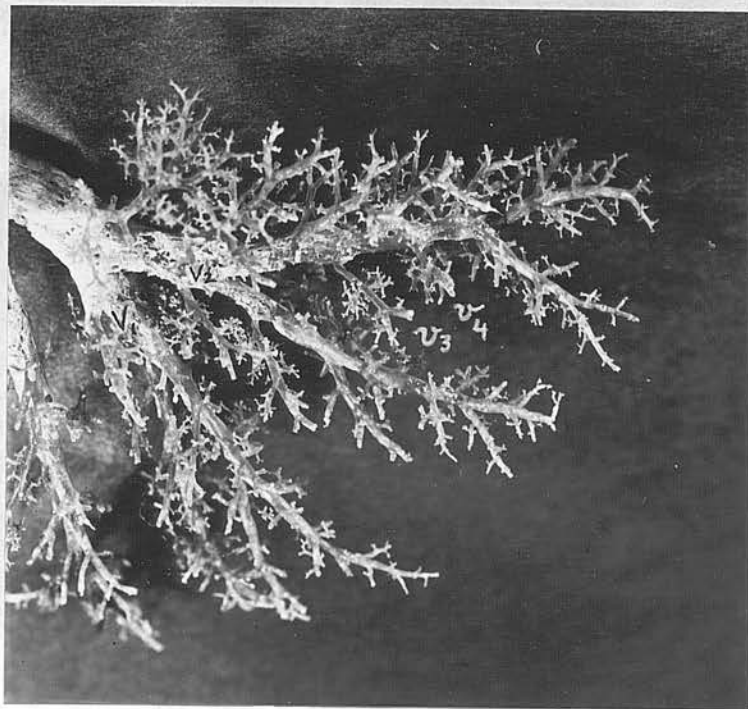
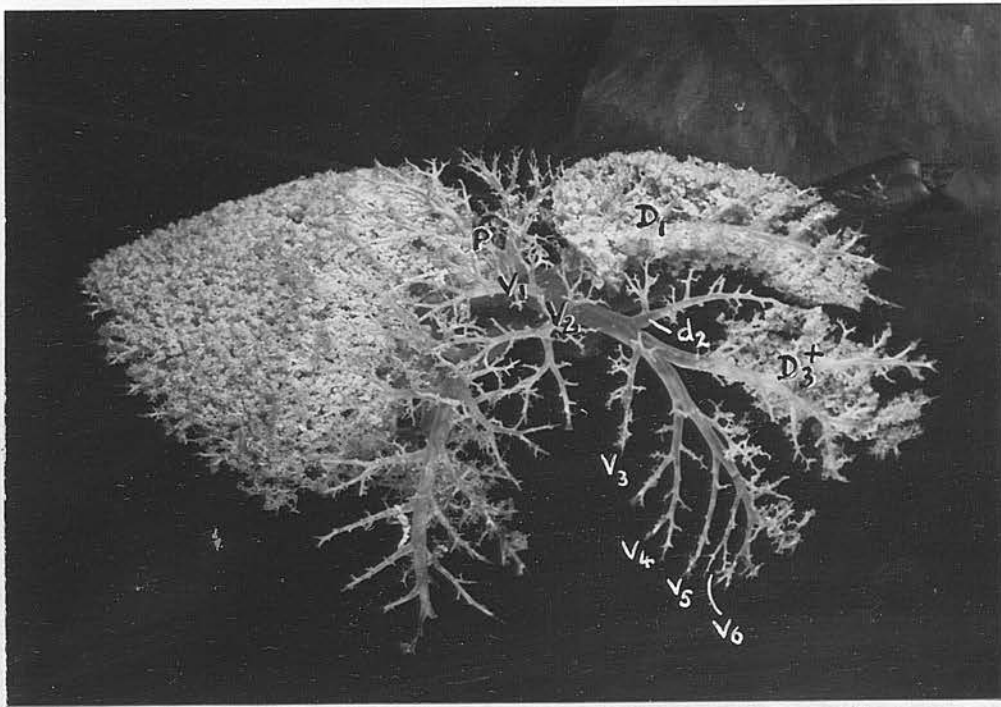
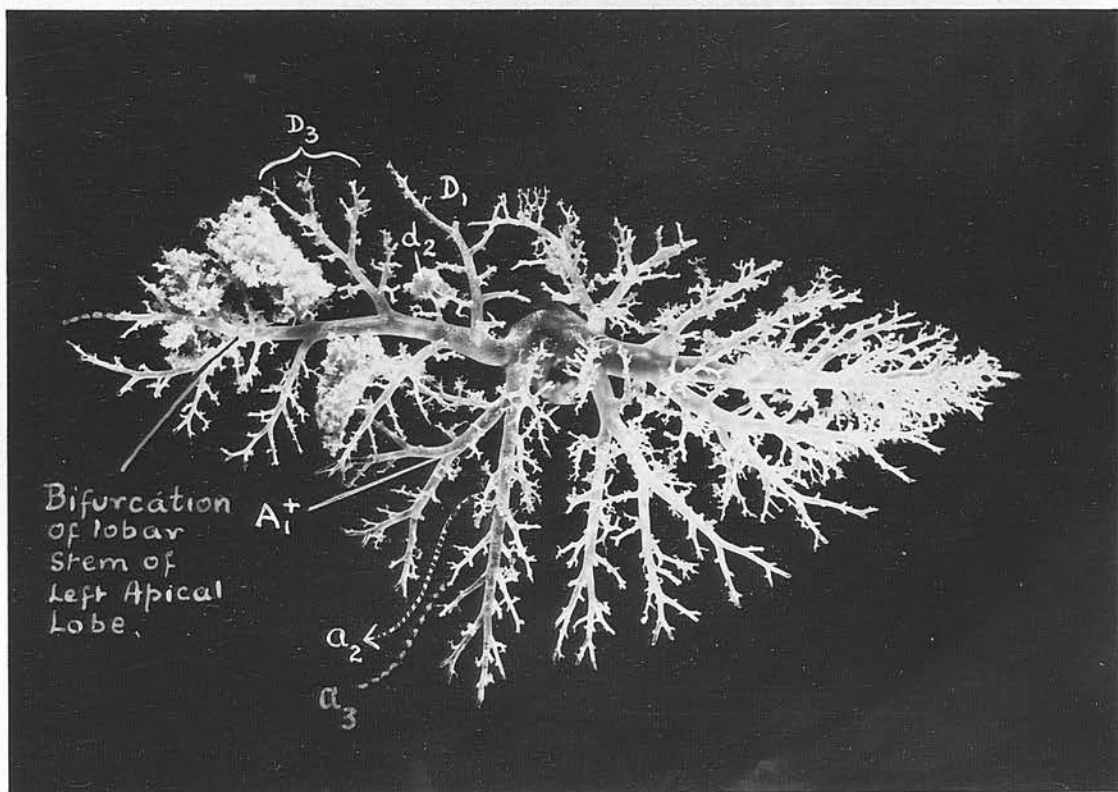


Fig. 23 . Celloidin cast of the bronchi of left Diaphragmatic Lobe of Dog's Lung. (Specimen E29)

Some regions, including right & left diaphragmatic lobes, have been left unprocessed.



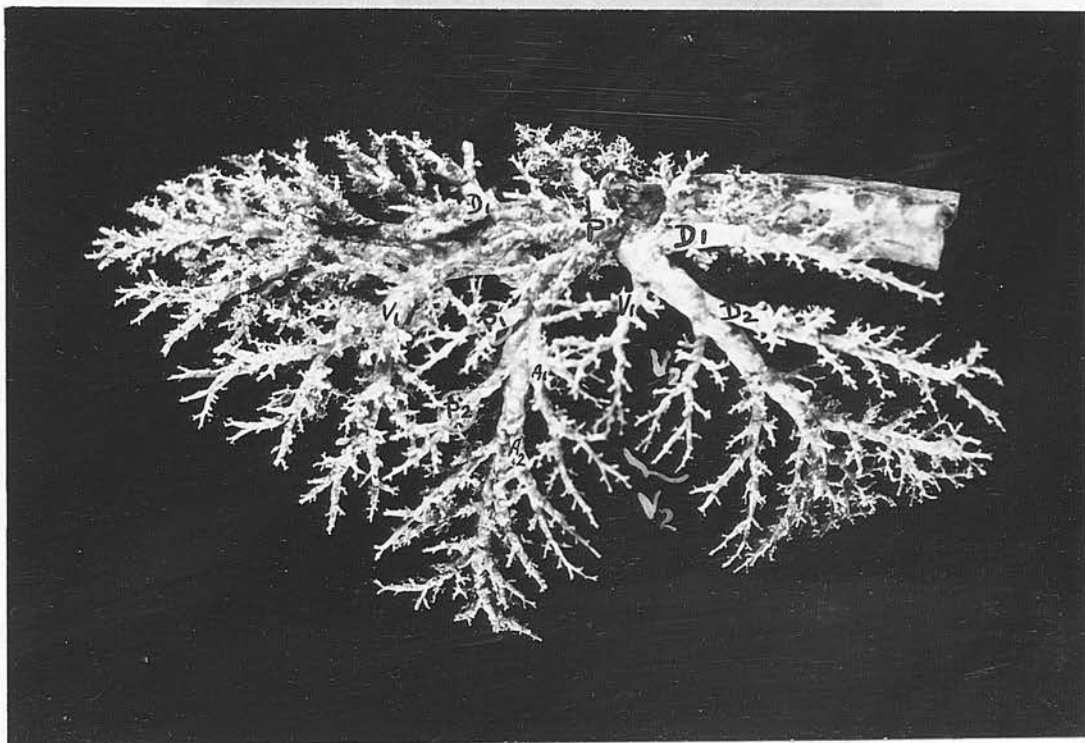
A. Right Lung



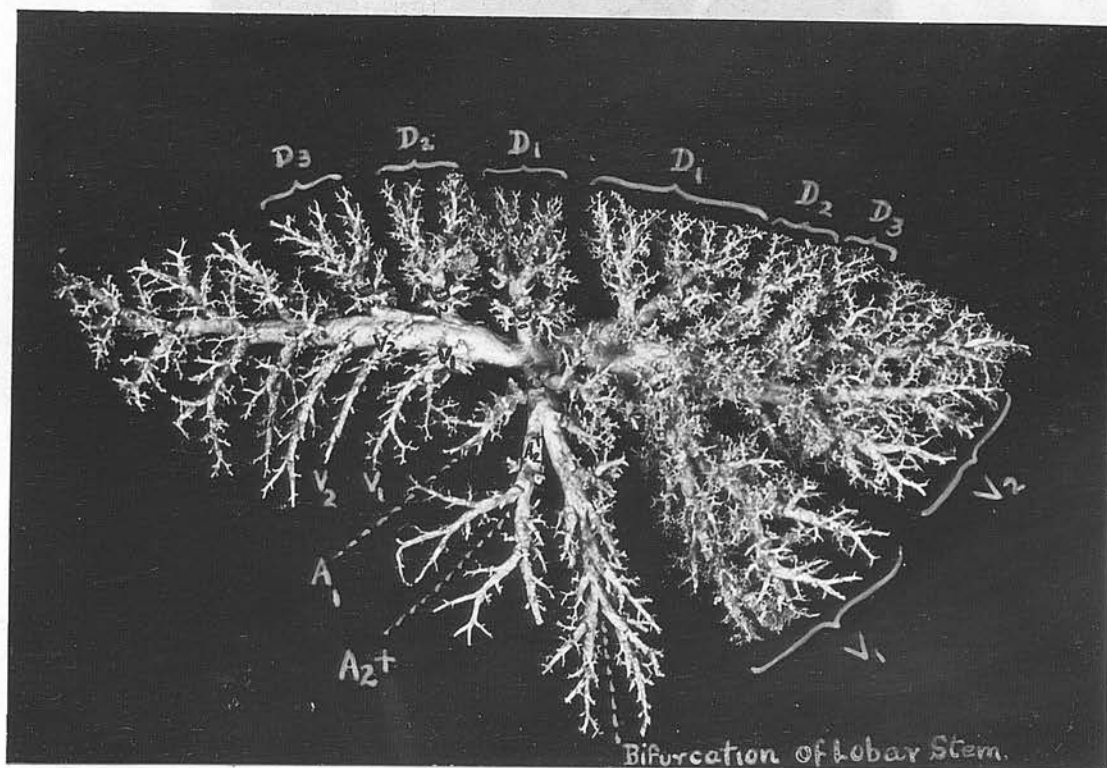
B. Left Lung

Fig. 24 ; A & B. Marco Resin cast of Bronchial Tree of Dog (Specimen E54).

Some regions, including right diaphragmatic lobe, have been left unpruned.

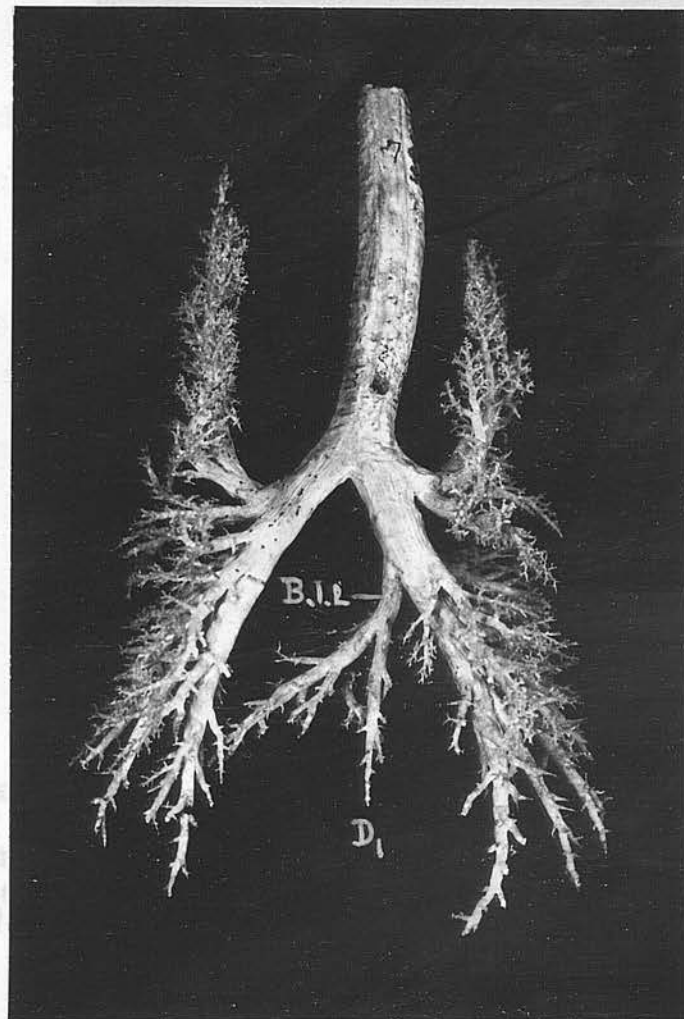


A. Right Lung

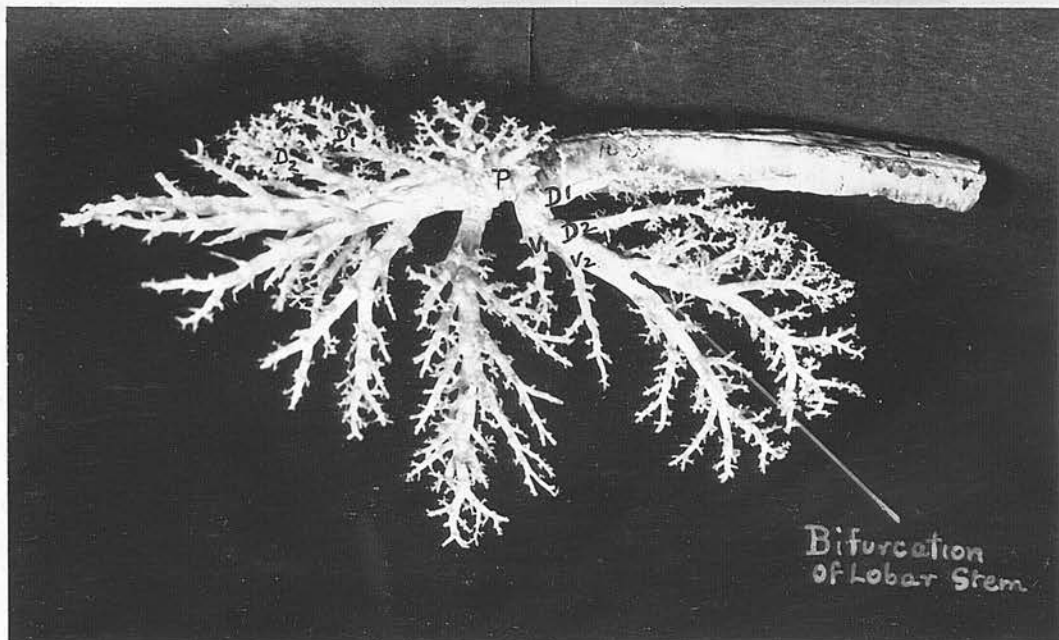


B. Left Lung.

Fig. 25 , A & B. Celloidin cast of the Bronchial Tree of Dog's Lungs. (Specimen E40)



A.



B

Fig. 26 . Celloidin cast of the bronchial tree of Dog (Specimen E7).
 A, Dorsal View. Some of the branches have been pruned
 to show the stem bronchus.
 B, Right Lateral View.

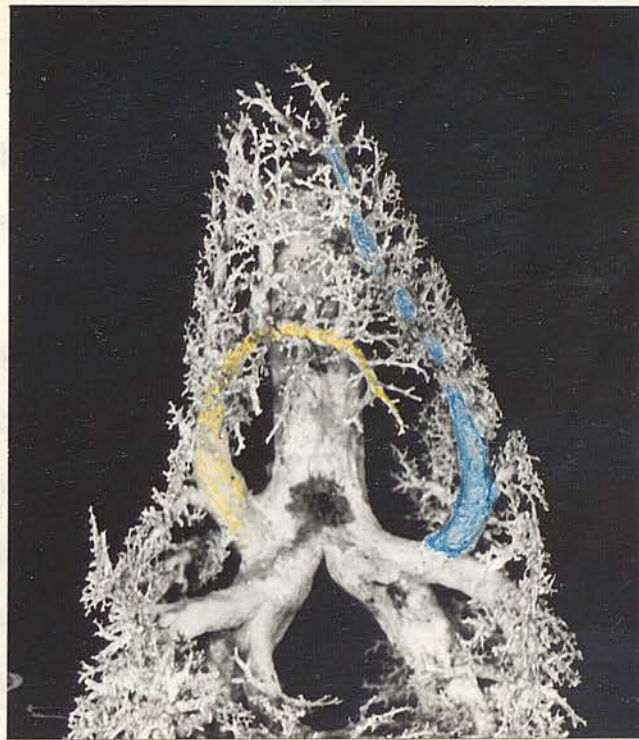


Fig. 27 . Ventral view of a celloidin cast of the bronchial tree of dog (Specimen E40), prepared from a pair of lungs hardened in situ to show the C-shaped cardiac curve of the lobar stem bronchus of right apical lobe, and the relatively straight course of the lobar stem of left apical lobe.

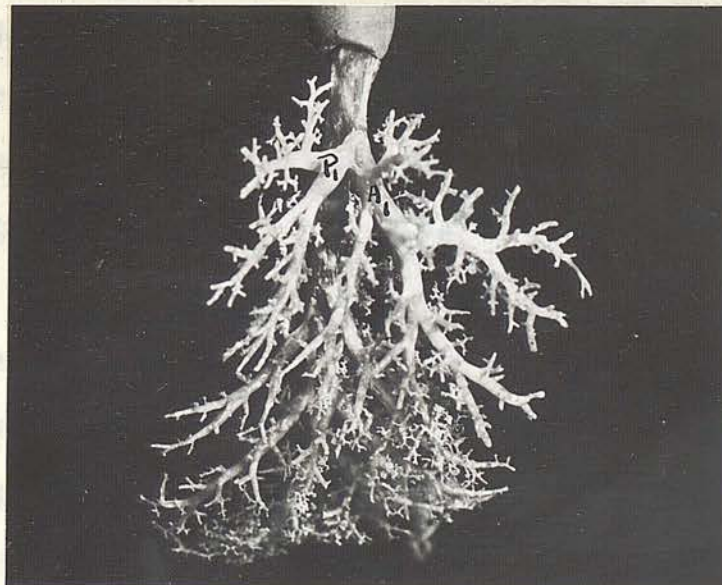


Fig. 28 . Dorso-lateral view of a celloidin cast of right cardiac lobe of dog (Specimen E45) to show the common origin of bronchi P_1 and A_1 .

NOMENCLATURE

The bronchovascular arrangement in dog's lung necessitates the introduction of a new method of denoting individual bronchi and vessels. The current nomenclature used in the case of human lung is not applicable to the dog.

It has already been mentioned that each of the seven lobes of dog possesses a lobar stem bronchus with two main series of branches, originating from its opposite aspects, and small irregular accessory branches arising from the circumference of the lobar stem bronchus, between the origins of the members of the two main series.

The direction of the lobar stem bronchus in each lobe determines the direction in which the two main series of bronchi and the accessory bronchi are disposed. In all but the cardiac lobes the main series run dorsally and ventrally. In the cardiac lobes they run in cephalic and in caudal directions. The accessory bronchi originate from the lateral and the medial aspects in all except the intermediate lobe in which they arise from the cephalic and the caudal aspects of the lobar stem bronchus. (Figs. , ,)

Both Aeby and Narath have used letters D and V to signify the dorsal and ventral branches of the main stem bronchi.

Huntington (1920), referring to the mammalian stem bronchus, proposed that "the derivatives from the axial canal" may be designated as "dorsal, dorso-medial, medial, ventro-medial, ventral, ventro-lateral, lateral, dorso-lateral", depicted in his Fig. 9 reproduced below:-

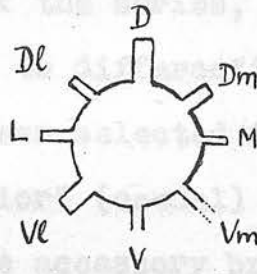


Fig 9 of Huntington (1920)
(Adapted)

These methods of denoting bronchi are in respect of the main stem bronchi and, because they continue on each side into the respective diaphragmatic lobe, these methods have been found to be applicable to the bronchi of these lobes only. Huntington's differentiation between lateral, dorso-lateral and ventro-lateral bronchi arising from the lateral aspect, and between medial, dorso-medial and ventro-medial bronchi arising from the medial aspect, has not been found to be necessary in this study.

Ewart's nomenclature and multiple other systems proposed later were exclusively meant for the human lung.

None of the nomenclatures mentioned above are applicable, in their entirety, to the bronchi of all the lobes of the dog's lung. Therefore, the following nomenclature is proposed:-

For the two main series of bronchi in both apical lobes, both diaphragmatic lobes and the intermediate lobe, the letters D and V are used to signify dorsal and ventral branches respectively.

In the cardiac lobes there are a cephalic and a caudal series of bronchi. The two adjectives "caudal" and "cephalic" do not provide any convenient letters as abbreviations for

denoting the members of the series, as both begin with the letter "C". In order to differentiate between the two, the letters A and P have been selected indicating "Anterior" (cephalic) and "Posterior" (caudal) directions in the dog.

With regard to the accessory bronchi in all lobes, except the intermediate lobe, the letters L and M, signifying "Lateral" and "Medial", are suitable. But in the intermediate lobe these branches originate from the cephalic and the caudal aspects. Once again these two adjectives do not help. For the sake of uniformity of lettering, the letters L and M are retained, this time to "signify" the caudal and the cephalic aspects respectively. (The cephalic aspect being the mediastinal aspect in this lobe, the letter M, the first letter of the word mediastinum, helps in associating M with "cephalic" branches).

To distinguish between branches supplying segments and "segmentellettes",* use has been made of capital letters for the former and small letters for the latter. Thus bronchi D, V, P and A represent segmental bronchi, and d, v, p and a stand for bronchi supplying segmentellettes. Since all lateral and medial branches supply segmentellettes, the capital letters L and M will not be encountered at all, and only the use of small letters l and m will be made. The same will apply to the branches L and M of the intermediate lobe.

Numerals have been added to denote the serial positions of bronchi counting from the hilar or proximal end of the lobe.

*The term "segmentellette" has been used by Neil and Gilmour (1946) to signify bronchi which are "accessory to a segment". In this study the term has been used for an under-developed segment.

Thus $A_1, A_2, A_3, A_4 \dots$, and $P_1, P_2, P_3, P_4 \dots$ represent the cephalic and the caudal series respectively in the ^{two} cardiac lobes; and $D_1, D_2, D_3, D_4 \dots$, and $V_1, V_2, V_3, V_4 \dots$ represent the dorsal and the ventral series in all the remaining lobes.

Replacing one or more of the capital letters in any of these series by a small letter, such as d_3 in the series $D_1, D_2, D_3, D_4 \dots$, indicates that the third dorsal segment, in the lobe concerned, is supplied by an under-developed bronchus and is, therefore, a segmentellette.

It was also found necessary to indicate bronchi in a series which were over-developed. Such bronchi have been indicated by the use of the arbitrary + sign. Thus in the series $D_1, D_2, D_3^+, D_4 \dots$ the third dorsal bronchus and, therefore, the corresponding segment is over-developed.

The accessory bronchi are represented by $\ell_1, \ell_2, \ell_3, \ell_4 \dots$ and $m_1, m_2, m_3, m_4 \dots$ indicating the order in which they appear, but it may be repeated here that these accessory bronchi do not form any definite serial arrangement.

The segments and segmentellettes are referred to by using the same symbols as those for the bronchi supplying them.

The arterial pattern resembles the bronchial pattern so closely that an artery accompanying a particular bronchus can be represented by the same symbol which represents the corresponding bronchus. Thus artery D_3 signifies the artery accompanying the third dorsal bronchus in a lobe.

Unlike the arteries, the veins generally lie in the inter-bronchial spaces and drain the adjoining segments. Any symbol for denoting a vein must indicate the areas or segments it drains. This has been done by indicating the adjoining segments.

Thus vein D_1-D_2 indicates the vein draining the first and the second dorsal segments of the lobe concerned. If a vein drains more than ^{two} / segments, the other segments are also indicated, e.g., vein $D_1-D_2-D_3$ (or vein $D_1-d_2-D_3$, if the second dorsal segment is a segmentellette). Similarly vein D_2-T would mean the vein running between and draining segments D_2 and T. (Letter T stands for the Terminal segment, explained on page 110).

It has also been necessary to refer to the interbronchial spaces in relation to the veins. These spaces have been denoted by using symbols of the adjoining bronchi. Thus space D_1-D_2 refers to the interval between bronchi D_1 and D_2 .

At the end it must be emphasised that the use of small letters to indicate segmentellettes and of the + signs to show the over-development of a bronchus has only been made where there has been the necessity of specifying these facts, otherwise only the capital letters have been used for segments and bronchi irrespective of their size.

It may also be pointed out that the use of the term "segment" (or "segmentellette") will be restricted to those areas which will be later established as segments. The areas supplied by bronchi other than the established segmental bronchi will be referred to simply as "areas", "territories" or "areas of distribution", etc.

Additional specific terms, the need for which will frequently arise in this study, and a few exceptions from the foregoing arbitrary rules, will be explained as the necessity arises.

THE LOBAR STEM BRONCHI OF INDIVIDUAL LOBES

The lobar stem bronchus of each of the right apical, the right cardiac, the right diaphragmatic, the intermediate, and the left diaphragmatic lobes, possesses a short extra-pulmonary and a long intra-pulmonary portion. The bronchi of the left apical and the left cardiac lobes do not possess extra-pulmonary portions as they originate from the common bronchus at the hilum of the two lobes. Their common bronchus, however, is wholly extra-pulmonary.

Some of the measurements done on bronchi are given in the Appendix , , but it may be mentioned here that the lengths of the extra-pulmonary portions of nearly all the lobar bronchi measured were less than 1 cm.

The bronchus of the right apical lobe, (Fig. 18, 27, 36B) the first branch of the right main bronchus, describes a C-shaped curve from its origin to its termination. It originates either opposite or slightly cephalic to the level of the tracheal angle. From its origin it runs transversely outwards and after a short course it enters the hilum. Soon after its entrance into the lobe it curves ventrally and cephalically, which direction it maintains for a considerable distance. In the distal part of the lobe it curves medially with a caudal inclination to reach the terminal end. Throughout its course it runs nearer the mediastinal than the costal surface of the lobe.

The bronchus of the right cardiac lobe, (Fig. 18, 26B, 36B) the second branch of the right main bronchus, proceeds from its origin ventro-laterally with or without a slight caudal inclination. After a short course of a few millimeters it enters the hilum. It then traverses the lobe, continuing in its original direction,

to reach the terminal end. It runs under the medial border of the lobe in the angle between the cardiac surface and the fissural surface for the diaphragmatic lobe.

The bronchus of the intermediate lobe (Figs. 18, 26A, 36B) is ^{off} given/just before the right stem bronchus disappears into the diaphragmatic lobe, from the medial and ventral aspect of the parent bronchus. The exact level of its origin varied in relation to the first dorsal bronchus, D_1 , of the diaphragmatic lobe. Its origin either preceded that of bronchus D_1 , or was at the same level, or immediately followed it (see Chart III). It proceeds in a caudal, ventral and medial direction to enter the lobar hilum. It traverses the lobe by running under its cephalic border to reach its terminal end.

The bronchus of the right diaphragmatic lobe (Figs. 18, 19, 36B) is the continuation of the right main bronchus, ^{and} traverses the lobe from its hilum to its terminal end, which corresponds to the most caudal end of the lung. During its course through the lobe it runs almost in the centre of the thick rounded dorsal border.

The common bronchus of the left apical and cardiac lobes (Figs. 18, 24B, 36B) originates as the first branch of the left main bronchus at a level caudal to the angle of the trachea. It runs ventrally and laterally, and after a short course divides at the hilum of the two lobes into respective lobar bronchi.

The apical lobe bronchus curves cephalically to traverse the lobe at an almost equal distance from the dorsal and ventral borders to reach the terminal end which in this lobe corresponds to the apex of the left lung.

The cardiac lobe bronchus runs a course identical to the course of the lobar bronchus of the right cardiac lobe. It

runs ventrally and slightly laterally with a caudal inclination running under the medial border, as on the right side, to reach the terminal end.

The bronchus of the left diaphragmatic lobe (Fig. 18, 20, 36 B.) the continuation of the left main bronchus, after it has given off the common bronchus of the left apical and cardiac lobes, has a course identical to the course of the right diaphragmatic lobe bronchus.

The Cardiac Curves

The two apical, the two cardiac and the intermediate lobes are all moulded round the heart. The respective lobar stem-bronchi may be imagined to be clasping the heart between them. They therefore possess curves the concavities of which are directed towards the heart. Each of these five lobar stem bronchi may thus be considered to possess a "cardiac curve". That of the right apical lobe, the C-shaped curve already described, is the most pronounced, while those of the left apical and left cardiac lobes are much less so.

The lobar stem bronchi of the diaphragmatic lobes possess curves which are parts of the general curves of the main bronchi described already. This general curve, in each stem bronchus, was described by Aebly, and termed by Ewart as the "cardiac curve"

(Fig. 18, 20, 36 A.)

The above mentioned points are best explained by referring to the series lobe by lobe.

THE DISPOSITION OF THE TWO MAIN SERIES OF BRONCHI
AND THE ACCESSORY BRANCHES ON THE LOBAR STEM BRONCHI

The Bronchi of the Main Series

The terms dorsal, ventral, cephalic and caudal, used to designate the series of bronchi, are likely to give an erroneous impression that the branches are arranged strictly in the directions indicated by them. It is necessary to point out that they indicate the directions and the aspects of origin of the branches from the lobar stem bronchi in a general sense only.

The two main series of bronchi, which have been stated already to arise in each lobe from the opposite aspects of the lobar stem bronchus, do not originate exactly opposite each other. The same has been pointed out by Aesby with regard to the branches of his stem bronchi. Here this remark is meant to be applied to all the lobar stem ^{bronchi of} dog's lungs.

The points of origins of the bronchi in the majority of the series are placed in an almost spiral manner round the lobar stems. The exact disposition of the planes, in which the series of bronchi lie, and the directions and aspects of their origins are influenced by the changing directions of the lobar stem bronchi.

A feature common to all the lobes is that branches of all the main series are generally directed away from the hilar region, so that they make acute angles with the lobar stem bronchi.
(Figs. 19, 20, 21A)

The above mentioned points are best explained by considering the series lobe by lobe.

The Right Apical Lobe

The arrangement of branches in this lobe is relatively more complicated than in the others.

The C-shaped cardiac curve of the lobar stem bronchus, referred to already, may for descriptive purposes be divided roughly into three parts - a proximal transverse part, a middle oblique part and a terminal medially directed part.

The first branch belonging to the V series (designated P bronchus for reasons to be stated later - vide page 118) originates from the caudal and lateral aspect of the curve where the first and the second parts of the lobar stem bronchus meet. The next branch (V_1) originates from the caudal, ventral and lateral aspect of the second part of the stem. The succeeding branches shift gradually at first to the ventral aspect and then to the caudal and ventral aspect of the third part. The directions in which these branches proceed correspond exactly to the aspects of the origins.

The "spiral" arrangement in the case of the dorsal series is not so well marked. The first dorsal branch (D_1) originates from the dorso-lateral and cephalic aspect of the oblique part of the stem. The successive branches shift to its dorsal aspect. The distal members of this series originate from the dorsal and cephalic aspect of the third part. The proximal branches are directed in a dorsal and cephalic direction towards the dorsal border. The distal ones are directed towards that part of the ventral border of the lung which lies between its apex and the terminal end of the lobe (Figs. 40 and 64A). They have a medial inclination.

The Left Apical Lobe

In this lobe the arrangement is simpler than in the right on account of a relatively straight course of the lobar stem bronchus (Figs. 20, 27). The first dorsal branch originates from the dorso-lateral and the first ventral branch from the ventro-lateral aspect of the lobar stem bronchus. Soon the origins "shift" to the dorsal and ventral aspects of the stem respectively. This arrangement then continues up to the apex of the lung. The branches are directed to the respective borders.

The Right Cardiac Lobe

In the right cardiac lobe the first cephalic branch (A_1) originates from the cephalic and lateral aspect, and the first caudal branch (P_1) from the caudal and lateral aspect of the lobar stem bronchus. Each successive branch, in each series, originates more and more from the cephalic and caudal aspects of the lobar stem bronchus respectively. Near the terminal end they originate almost from the opposite aspects. The two series are directed to their respective borders.

The Left Cardiac Lobe

In the left cardiac lobe the arrangement is similar to that in the right cardiac except that the origins of the caudal series are slightly more lateral and those of the cephalic series more cephalic. The branches of the caudal series are shorter in the left lobe than in the right. (cf. Figs. 19 and 20)

The Right and Left Diaphragmatic Lobes

In the two diaphragmatic lobes the arrangement is exactly similar. The first branch of the dorsal series (D_1) originates

from the dorso-lateral aspect and is directed dorso-laterally. The terminal dorsal bronchi originate from the dorsal or dorso-medial aspect of the stem. The intervening branches occupy intermediate positions.

The first branch of the ventral series (V_1) in each diaphragmatic lobe originates from the ventro-lateral aspect and each successive branch more and more from the lateral aspect so much so that the terminal branches are almost lateral to the stem bronchus. These latter branches ought, really, to be labelled as lateral (L) branches but the change of their origins from the ventral aspect to the lateral is so uniformly gradual that one is forced to consider them in series with V-branches.*

The Intermediate Lobe

The lobar bronchus of this lobe may be divided roughly into two parts. The first part extends caudally, ventrally and medially. Soon after entering the hilum it curves to become the second part which traverses the lobe obliquely running ventrally and towards the left, caudal to the heart, to terminate at the ventral (terminal) end.

The first dorsal branch (D_1) originates from the dorsal, lateral and caudal aspect of the lobar stem bronchus proximal to or at the curve joining the first and the second parts, and is directed almost caudally. (See Fig. 21A, in which it appears to proceed dorsally on account of the angle at which the photograph was taken.) The succeeding branches arising from the second part "shift" to the dorsal aspect of the stem. The dorsal series of branches is directed towards the dorsal border of the lobe.

* It may be noted that Flint called the whole series of ventral branches in pig as the Lateral branches (Vide page /6).

The ventral series do not exhibit any "shifting" of the origins. They all arise from the ventral aspect of the second part of the lobar stem and are directed to the ventral border of the lobe.

The Accessory Bronchi
("m" and "l" bronchi)

The accessory bronchi arise from those areas of the lobar stem bronchi which lie between the origins of the two main series.

None of the accessory bronchi were arranged in definite series, except some of the m-bronchi which in some specimens showed a tendency to be arranged in series. Such examples were found to exist in the regions of the mediastinal crest of some of the right apical lobes, the crests of nearly all the cardiac lobes of both sides, and the cephalic border of the intermediate lobe. No examples of such "subsidiary" series were found in the two diaphragmatic and the left apical lobes. The l-bronchi did not exhibit such an arrangement in any of the lobes.

It will be appreciated from the above that the number of branches counted in a lobe can be given as very close to approximate value.

DETAILED OBSERVATIONS ON THE BRANCHES
OF THE LOBAR STEM BRONCHI

The following observations were made in each lobe:-

1. The sequence of origin of the branches from the lobar stem bronchus.
2. The size of each branch in terms of the three categories of bronchi mentioned already, i.e., over-developed, normal and under-developed bronchi.
3. The number of branches arising from the lobar stem bronchus.
 - (a) The total number
 - (b) The number of branches in each series
 - (c) The number of "m" and "l" accessory branches.

These branches were studied as far as it was possible to identify the serial and the accessory bronchi on the lobar stem bronchi. Beyond this point, in a large number of specimens a variable number of minute irregular branches were recognisable which were ignored on account of their insignificant size. However, their approximate number was noted simply for the sake of completeness of observations.

In the casts the maximum number of branches depends upon the extent to which the lobar stem bronchus is injected. In some of them the branches at the extreme ends of the lobar stem bronchi failed to be completely injected and the stem bronchus ended abruptly with distal branches appearing either as small knobs or stumps.

It will be appreciated from the above that the maximum number of branches counted in a lobe can be given no more than an approximate value.

It has previously been mentioned that in some lobes the lobar stem bronchus undergoes^a/bifurcation at variable distances from their terminal ends. In such cases the branches arising from a lobar stem bronchus were studied up to the point of bifurcation, as beyond this point the individuality of the stem bronchus was lost. Such examples of bifurcation were also recorded.

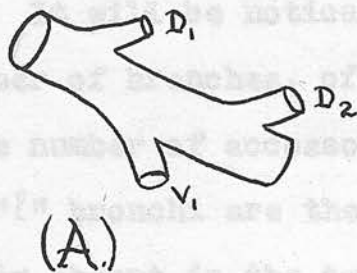
In recording the sequence in which the bronchi originate, every branch, howsoever small or large, and irrespective of its being a member of a main series or of its being an accessory bronchus, was taken into account.

Usually the bronchi were found to arise from the lobar stem bronchus distinctly one after the other. Not infrequently difficulty was experienced in deciding which of the two bronchi preceded the other. The various types of situations met with are diagrammatically represented in Fig.29 .

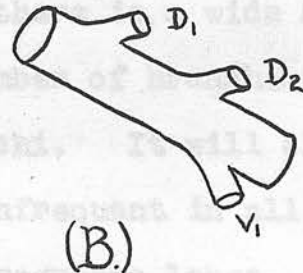
In Figs.29A and 29B the order of branches is obvious. Difficulty is encountered in Fig.29c in which branches D_2 and V_1 appear to arise at the same level. Attention in such a case was paid to the levels of their keels indicated by arrows in the diagrams. As the point of the keel of branch D_2 precedes that of branch V_1 , the former was presumed to have made its appearance first on the stem bronchus. The order of branches in this figure has been shown to be D_1, D_2, V_1 . The rounded contours of the obtuse angles which the branches make with the lobar stem bronchus provide no fixed points which could be taken to decide this matter.

In Fig.29D, branches D_2 and V_1 are opposite each other as their keels are at the same levels. The order of branches in this figure is represented as $D_1, D_2/V_1$, or $D_1, V_1/D_2$, the oblique line indicating that the origins of D_2 and V_1 are at the same level.

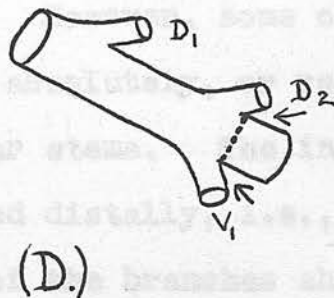
Order $D_1, V_1, D_2 \dots$



Order $D_1, D_2, V \dots$



Order $D_1, D_2/V_L \dots$



Order $D_1, D_2, V_1 \dots$

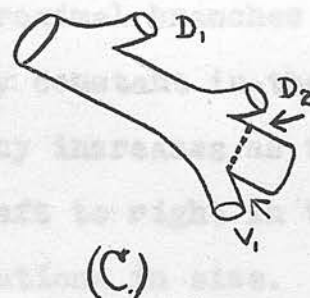


Fig. 29.

Schematic representation of different types of arrangement of branches on the lobar stem bronchi. Three hypothetical branches D_1 , D_2 and V_1 have been shown on the lobar stem bronchus. The order of branches is indicated above each figure.

All the above-mentioned observations were made in each lobe separately and are recorded in Charts I, II, III, IV, V, VI, VII. using the system of denotation of bronchi explained under nomenclature.

Table 4 summarizes the number of branches of the lobar stem bronchi. It will be noticed that there is a wide range of the total number of branches, of the number of branches in each series, and of the number of accessory bronchi. It will also be noticed that the "l" bronchi are the most infrequent in all the lobes and totally absent in the two diaphragmatic lobes.

From the Charts it can be seen that the sequence of origin of branches is extremely variable so that no two bronchial trees are alike. However, some of the proximal branches in each lobe are either absolutely, or relatively constant in their position on the lobar stems. The inconstancy increases as the branches are followed distally, i.e., from left to right in the Charts.

Most of the branches show variations in size. A certain branch may be of a normal size in one lobe, overdeveloped in another, and underdeveloped in yet another lobe. (For example - bronchus V_3 in right apical lobe (Chart I, Specimens M3, M1 and M5 respectively)). All accessory branches are small.

Bifurcation of the lobar stem bronchus, observed in some lobes, takes place after a variable number of side branches have been given off.

CHART I BRONCHIAL TREE OF DOG
 - Branches of Lobar Stem Bronchus of RIGHT APICAL LOBE.
 (37 Specimens).

Specimen No.		Numerical Order of Branches.																								Additional Branches.	Total No of Branches.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
M	1	P	D ₁	V ₁	D ₂ /V ₂	V ₃ ⁺ /l ₁	m ₁	l ₂ /D ₃	m ₂	l ₃	m ₃	D ₄	m ₄	←													15
"	2	P	D ₁	V ₁	D ₂	V ₂	l ₁	D ₃	V ₃	V ₄	D ₄	l ₂	m ₁	V ₅	l ₃ /m ₂											6	21
"	3	P	D ₁ /V ₁	d ₂	V ₂	D ₃	V ₃	l ₁	m ₁	D ₄	m ₂	V ₄	V ₅	l ₂ /D ₅	m ₃	D ₆	m ₄									5	23
"	4	P	D ₁ /V ₁	V ₂	d ₂	V ₃ ⁺ /D ₃	V ₄	m ₁	l ₁	m ₂ /V ₅	l ₂	m ₃ /d ₄	V ₆	D ₅	l ₃	D ₆ /V ₇	D ₇									3	24
"	5	P	D ₁	V ₁	D ₂ /V ₂	V ₃ ⁺	D ₃ ⁺	l ₁	V ₄	m ₁	d ₄	V ₅	m ₂	V ₆ /d ₅	m ₃ ⁺	←											16
"	6	P	D ₁ /V ₁	V ₂ /l ₁	d ₂	V ₃	D ₃	V ₄ /m ₁	D ₄	V ₅	m ₂	D ₅	V ₆	m ₃	l ₂	D ₆	m ₄	l ₃	←								20
"	7	P	D ₁ ⁺ /V ₁	V ₂ ⁺	V ₃ ⁺	l ₁	l ₂	m ₁	V ₄	d ₂ /m ₂	l ₃	D ₃	m ₃	l ₄	←												15
"	8	P	D ₁	V ₁	D ₂	V ₂	l ₁	V ₃ ⁺	D ₃ ⁺ /V ₄	m ₁	D ₄ /V ₅	m ₂	l ₂ /V ₆	d ₅	m ₃	←											17
"	9	P	D ₁	V ₁	D ₂	V ₂	m ₁	l ₁	V ₃	D ₃	l ₂	m ₂	D ₄	l ₃	V ₄	m ₃	l ₄	m ₄	l ₅	D ₅	m ₅				3	23	
"	10	P	D ₁	V ₁	d ₂ /V ₂ ⁺	l ₁	D ₃	V ₃ /m ₁	d ₄	D ₅ ⁺ /V ₄	m ₂	l ₂	m ₃	V ₅ /d ₆	m ₄	l ₃	m ₅	D ₇								3	24
"	11	P	D ₁	V ₁	V ₂	d ₂	V ₃ ⁺	D ₃ ⁺	V ₄	l ₁	m ₁	V ₅	d ₄	m ₂	l ₂	V ₆	d ₅	m ₃ /V ₇	l ₃	D ₆					5	25	
"	13	P	D ₁	V ₁	V ₂	d ₂	V ₃	D ₃	V ₄	D ₄	m ₁	V ₅	D ₅ /m ₂	m ₃ /V ₆	D ₆	m ₄	D ₇	l ₁	D ₈						2	22	
"	14	P	D ₁	V ₁	V ₂	D ₂	V ₃	D ₃ /l ₁	V ₄	m ₁	D ₄	l ₂	m ₂ /V ₅	l ₃	m ₃ /V ₆	V ₇	m ₄ ⁺								4	23	
"	16	P	D ₁	V ₁	D ₂	V ₂ ⁺	V ₃	D ₃	l ₁	D ₄	V ₄	m ₁	l ₂	D ₅ /V ₅	m ₂	l ₃	m ₃	D ₆	V ₆						2	21	
E	3	P	D ₁	V ₁	d ₂	V ₂	D ₃	V ₃	D ₄ /V ₄	V ₅ /m ₁	d ₅	m ₂	D ₆ ⁺	V ₆	m ₃	V ₇									3	20	
"	4	P	D ₁	V ₁	D ₂	V ₂	l ₁ /V ₃	d ₃	l ₂	D ₄ ⁺	m ₁ /V ₄	d ₅	V ₅	m ₂	l ₃	D ₆									3	20	
"	7	P	D ₁	V ₁	D ₂	V ₂	m ₁	←																			6
"	11	P	D ₁	V ₁	d ₂	V ₂	V ₃ ⁺	D ₃ ⁺	V ₄	m ₁	V ₅	m ₂	V ₆	l ₁	m ₃	d ₄ ⁺	V ₇ ⁺	m ₄	D ₅	V ₈					3	22	
"	13	P	D ₁	V ₁	V ₂	d ₂	V ₃	d ₃	V ₄	m ₁	D ₄	V ₅	m ₂	l ₁	D ₅	V ₆ ⁺	V ₇ /m ₃	m ₄	l ₂ /V ₈						2	22	
"	14	P	D ₁	V ₁	d ₂	V ₂	d ₃	m ₁	V ₃	V ₄	D ₄	m ₂	V ₅	l ₁ /D ₅	m ₃	l ₂	m ₄ ⁺ /V ₆	D ₆	l ₃ /m ₅	D ₇					5	27	
"	15	P	D ₁	V ₁	V ₂	D ₂	V ₃	l ₁	D ₃ ⁺	V ₄ /l ₂	m ₁	d ₄	V ₅	m ₂	l ₃	V ₆	d ₅	m ₃	d ₆	m ₄	m ₅	l ₄				22	
"	17	P	D ₁	V ₁	l ₁	D ₂	V ₂	D ₃	l ₂	V ₃ /m ₁	D ₄	m ₂	←														12
"	20	P	D ₁	V ₁	V ₂	D ₂	m ₁ /V ₃	D ₃ ⁺	V ₄ /m ₂	d ₄	m ₃	V ₅	D ₅	m ₄	l ₁	←											16
"	21	P	D ₁	V ₁	D ₂ /V ₂	V ₃	d ₃	V ₄	D ₄ ⁺	V ₅	m ₁	d ₅	V ₆	d ₆	m ₂	l ₁	V ₇	←									17
"	22	P	D ₁	V ₁	V ₂	d ₂	V ₃	d ₃	l ₁	V ₄ ⁺	m ₁	D ₄	l ₂ /m ₂	D ₅	l ₃ /m ₃	D ₆									6	23	
"	29	P	D ₁	V ₁	V ₂	D ₂	V ₃	d ₃ /V ₄	m ₁	D ₄	V ₅	m ₂	D ₅ /V ₆	m ₃	V ₇	d ₆	m ₄	l ₁ ⁺	D ₇	l ₂	m ₅	D ₈				23	
"	30	P	D ₁	V ₁	D ₂	V ₂	l ₁	d ₃ /V ₃	V ₄ ⁺	D ₄	m ₁	D ₅	V ₅	m ₂	l ₂ ⁺	m ₃	d ₆								13	30	
"	33	P	D ₁	V ₁	D ₂	V ₂	d ₃	V ₃	←																		7
"	34	P	D ₁	V ₁	D ₂	l ₁	D ₃ /V ₂	V ₃ ⁺	D ₃ ⁺	V ₄	m ₁ /l ₂	V ₅	d ₅	V ₆	m ₂ ⁺	l ₃	m ₃ ⁺	V ₇	D ₆						5	25	
"	36	P	D ₁	V ₁	D ₂	V ₂	d ₃	V ₃	D ₄	l ₁	V ₄ ⁺	D ₅ ⁺	V ₅	m ₁	V ₆	l ₂	m ₂	V ₇	D ₆	m ₃	V ₈	m ₄ /D ₇ ⁺				22	
"	40	P	D ₁	V ₁	V ₂ /D ₂	V ₃ ⁺	m ₁ /l ₁	V ₄	m ₂	D ₃ ⁺	m ₃	V ₅	d ₄	m ₄	V ₆ /d ₅	m ₅	D ₆	V ₇	m ₆	m ₇ ⁺	V ₈	m ₈	←				24
"	45	P	D ₁	V ₁	D ₂	V ₂	V ₃ ⁺	D ₃ ⁺	V ₄	d ₄	m ₁	V ₅	d ₅	m ₂ /m ₃	V ₆	d ₆	D ₇	m ₄	l ₁	←							19
"	52	P	D ₁	V ₁	V ₂	D ₂	V ₃	d ₃	l ₁	V ₄ /m ₁	D ₄ ⁺	l ₂	m ₂	V ₅	d ₅	l ₃ /m ₃	D ₆								4	22	
"	53	P	D ₁	V ₁	D ₂	V ₂	V ₃	m ₁ ⁺	l ₁	←																	8
"	54	P	D ₁	V ₁	V ₂	d ₂	V ₃	D ₃ ⁺	V ₄	l ₁	m ₁	V ₅	m ₂	l ₂	V ₆	m ₃	l ₃	D ₄	m ₄	←							18
"	55	P	D ₁	V ₁	D ₂	V ₂	m ₁	l ₁	V ₃ /m ₂	d ₃	m ₃	V ₄ ⁺	D ₄	m ₄	l ₂	m ₅	D ₅ ⁺	l ₃ ⁺	m ₆ ⁺	l ₄ ⁺	←						20
"	56	P	D ₁	V ₁	d ₂ ⁺	V ₂	D ₃	l ₁	V ₃	m ₁	D ₄	m ₂	V ₄ /m ₃	D ₅	m ₄	V ₅	m ₅	D ₆								5	23

← = Bifurcation of
 Lobar Stem Bronchus.

CHART II BRONCHIAL TREE OF DOG

- Branches of the Lobar Stem Bronchus of RIGHT CARDIAC LOBE
(33 Specimens):

- Branches of the Lobar Stem Bronchus of RIGHT CARDIA.																												
Specimen No.		Numerical Order of Branches.																								Additional Branches.	Total No. of Branches.	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24			
M	1	P ₁	A ₁	P ₂	A ₂	P ₃	m ₁	A ₃ /P ₄	m ₂	A ₄	P ₅	m ₃ /a ₅	A ₆	m ₄	P ₆	A ₇	m ₅	h ₇	A ₈ /h ₈	P ₉	A ₉	P ₁₀					24	
"	2	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	A ₃	m ₂	P ₄ /A ₄	m ₃	A ₅	P ₅	m ₄	A ₆	h ₆	l ₁	m ₅	P ₇	A ₇	h ₈	m ₆	←				22	
"	3	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	l ₁	A ₃ /m ₂	P ₄	l ₂	m ₃	A ₄	l ₃	P ₅	l ₄	m ₄	l ₅	P ₆	A ₅	←						20	
"	4	P ₁	A ₁	P ₂	A ₂	P ₃ /m ₁	A ₃ /m ₂	m ₃	l ₁ /P ₄	m ₄	A ₄	A ₅	l ₂	m ₅	h ₅	l ₃ /m ₆	P ₆	l ₄	m ₇	l ₅	←						23	
"	5	P ₁	A ₁	P ₂	A ₂	P ₃ ⁺	l ₁	A ₃ ⁺	m ₁	l ₂	m ₂	l ₃	m ₃	A ₄ ⁺	l ₄	m ₄	l ₅	m ₅	l ₆	m ₆	l ₇	P ₄					21	
"	6	P ₁	A ₁	P ₂	A ₂ ⁺ /m ₁	P ₃	m ₂	P ₄	m ₃	h ₅ /a ₃	m ₄ /P ₆	a ₄	P ₇	l ₁	m ₅	P ₈	a ₅	l ₂	h ₉								21	
"	7	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	m ₂ /A ₃	m ₃	P ₄	A ₄	m ₄	P ₅ /A ₅	m ₅	l ₁ /A ₆	l ₂ /P ₆	A ₇	P ₇	l ₃	A ₈	←						23	
"	8	P ₁	A ₁	P ₂	A ₂	A ₃	m ₁	P ₃	←																			7
"	9	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	A ₃	m ₂	l ₁	P ₄	m ₃	A ₄	m ₄	l ₂	P ₅	A ₅	m ₅	l ₃	P ₆	l ₄						20	
"	10	P ₁	A ₁	P ₂	A ₂ ⁺	m ₁	l ₁	P ₃	A ₃	m ₂	P ₄	a ₄	P ₅	l ₂	A ₅	l ₃	m ₃	a ₆	h ₆	a ₇	l ₄	P ₇					24	
"	11	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃ ⁺	A ₃	m ₂	A ₄ /m ₃	l ₁	m ₄	l ₂	m ₅	m ₆	P ₄ /l ₃	A ₅	m ₇	A ₆								20	
"	13	P ₁	A ₁	P ₂ ⁺	A ₂	m ₁	h ₃	A ₃ ⁺	m ₂	l ₁ /h ₄	m ₃	h ₅	P ₆	m ₄	l ₂	←											15	
*	" 14	P ₁ /A ₁	P ₂ /A ₂	m ₁	P ₃	A ₃	m ₂	P ₄	A ₄	m ₃	l ₁	a ₅	h ₅	m ₄	A ₆	P ₆	A ₇	m ₅	l ₂	P ₇							20	
"	16	P ₁	A ₁ /P ₂	P ₃	A ₂	m ₁	P ₄	A ₃	P ₅	m ₂	A ₄	P ₆ /A ₅	m ₃	P ₇	A ₆ /m ₄	h ₈ /A ₇	A ₈	P ₉									23	
E	3	P ₁	A ₁	P ₂	A ₂	h ₃	A ₃	P ₄	m ₁	P ₅	a ₄	a ₅	P ₆ /m ₂	a ₆	m ₃												22	
"	7	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	m ₂	A ₃	m ₃	P ₄	m ₄	a ₄ /P ₅	m ₅ /m ₆	l ₁	m ₇	←										17	
"	13	P ₁	A ₁	P ₂	A ₂ ⁺	m ₁	P ₃	a ₃	P ₄ /m ₂	A ₄	P ₅ /m ₃	m ₄	A ₅	m ₅	P ₆												21	
"	14	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	A ₃	m ₂	P ₄	A ₄	m ₃	P ₅	A ₅ /m ₄	h ₆	m ₅	a ₆	a ₇	P ₇	m ₆	A ₈						24	
"	15	P ₁	A ₁	P ₂	A ₂	P ₃	m ₁	A ₃ ⁺	P ₄	m ₂	P ₅	l ₁	a ₄	l ₂	m ₃	l ₃	a ₅	P ₆	m ₄ /l ₄	←							19	
*	" 20	P ₁ /A ₁	P ₂	A ₂	P ₃	A ₃ /m ₁	m ₂	A ₄	P ₄	m ₃	l ₁	h ₅	A ₅	m ₄	l ₂	h ₆	m ₅	P ₇ [?]									23	
*	" 21	P ₁ /A ₁ ⁺	P ₂	a ₂	P ₃	m ₁	a ₃	m ₂	l ₁	m ₃	P ₄	l ₂	m ₄	m ₅	←												13	
"	22	P ₁	A ₁	P ₂	A ₂ ⁺	P ₃	m ₁	P ₄	m ₂	l ₁	m ₃	m ₄	l ₂	m ₅	P ₅	l ₃	m ₆	←									16	
"	29	P ₁	A ₁	P ₂	A ₂	P ₃	A ₃	m ₁	P ₄	A ₄	P ₅	m ₂	l ₁	a ₅	m ₃	P ₆											21	
"	30	P ₁	A ₁	P ₂	A ₂	P ₃	m ₁	A ₃	P ₄	A ₄ ⁺	m ₂	P ₅															18	
*	" 33	P ₁ /A ₁	P ₂	A ₂	P ₃ /A ₃	A ₄	m ₁	P ₄ /l ₁	m ₂	A ₅	l ₂	m ₃	P ₅	A ₆	m ₄	P ₆											26	
"	36	P ₁	A ₁	P ₂	A ₂	←																					4	
"	40	P ₁	A ₁	P ₂	A ₂	m ₁	P ₃	m ₂	A ₃	h ₄	m ₃	h ₅	m ₄ /P ₆	A ₄	m ₅ /l ₁	m ₆ /P ₇	A ₅										19	
*	" 45	P ₁ /A ₁	P ₂	A ₂	P ₃	A ₃	m ₁	P ₄	m ₂	P ₅	A ₄	m ₃	A ₅	h ₆	l ₁ /m ₄	h ₇	a ₆										17	
"	52	P ₁	A ₁	P ₂	A ₂	←																					4	
"	53	P ₁	A ₁	P ₂	A ₂	P ₃	A ₃	m ₁ /P ₄	A ₄	P ₅ /m ₂	m ₃	l ₁	a ₅	h ₆	m ₄	A ₆ ⁺	h ₇	m ₅	P ₈	l ₂ [?]	m ₆	←					22	
"	54	P ₁	A ₁ /P ₂	A ₂ /m ₁	P ₃	m ₂	A ₃	P ₄	m ₃ /P ₅	A ₄	a ₅ [?]	P ₆	m ₄	P ₇	←												16	
"	55	P ₁	A ₁	P ₂ /A ₂	A ₃	P ₃	m ₁	A ₄	P ₄	m ₂ /l ₁	P ₅																15	
"	56	P ₁	m ₁	A ₁	P ₂	A ₂	m ₂	P ₃	l ₁	m ₃	m ₄	A ₃	h ₄	m ₅	P ₅ /a ₄	l ₂	m ₆	←									17	

← = Bifurcation of Lobar Stem Bronchus.

* In these specimens bronchi P₁ and A₁ arise by a common stem. The first branch to arise from the lobar stem bronchus in these specimens is this stem. Bronchi P₁ and A₁ have, therefore, been placed together in the first square.

CHART III BRONCHIAL TREE OF DOG

-Branches of Lobar Stem Bronchus of RIGHT DIAPHRAGMATIC LOBE
(31 Specimens).

Specimen No.		Numerical Order of Branches.																								Additional Branches	Total No. of Branches
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		
M	1	•	D ₁	V ₁	D ₂	m ₁	V ₂	m ₂	D ₃	m ₃	V ₃ /m ₄	D ₄	v ₄	m ₅	V ₅	D ₅	m ₆	V ₆	m ₇	V ₇					2	21	
"	2	•	/D ₁	V ₁	D ₂	m ₁	V ₂	D ₃	m ₂	m ₃	V ₃	m ₄	D ₄	m ₅	V ₄	m ₆	D ₅	←									15
"	3	•	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	m ₂	m ₃ /V ₃	m ₄	D ₄	V ₄	m ₅ /m ₆	V ₅	m ₇	D ₅	m ₈	V ₆						2	21	
"	4	•	D ₁	V ₁	D ₂	m ₁	m ₂	V ₂	m ₃	D ₃	m ₄	V ₃	D ₄	m ₅	m ₆ /V ₄	m ₇	D ₅	V ₅	m ₈						3	21	
"	5	•	D ₁ /V ₁	D ₂ /V ₂	D ₃	m ₁	V ₃	m ₂	D ₄	m ₃	m ₄	V ₄	D ₅ /m ₅	V ₅	D ₆										3	19	
"	6	•	/D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	m ₂	v ₃	D ₄	m ₃	V ₄	D ₅	v ₅	m ₄	V ₆	D ₆	V ₇						5	22	
"	7	•	/D ₁	V ₁	D ₂	V ₂	m ₁	m ₂	D ₃ /V ₃	m ₃	D ₄ /m ₄	m ₅	V ₄	D ₅	V ₅										3	18	
"	8	•	/D ₁	V ₁	D ₂	V ₂	m ₁	m ₂	D ₃	V ₃	m ₃	D ₄	m ₄	m ₅	V ₄	D ₅	m ₆	m ₇ /V ₅	D ₆						5	23	
"	9	•	D ₁	V ₁	D ₂	m ₁	V ₂	D ₃ /m ₂	m ₃	m ₄	V ₃ /D ₄	m ₅	D ₅	v ₄	V ₅ /m ₆	D ₆	m ₇	V ₆	D ₇						3	23	
"	10	•	D ₁	V ₁	D ₂	V ₂	m ₁	m ₂	D ₃	m ₃	V ₃	m ₄	D ₄	m ₅ /V ₄	D ₅	m ₆	D ₆ /V ₅	m ₇	V ₆ /D ₇	←						20	
"	11	•	/D ₁	V ₁	D ₂	V ₂	D ₃ /m ₁	m ₂	V ₃	D ₄	m ₃	m ₄	D ₅	V ₄	m ₅	D ₆ /V ₅	m ₆	V ₆ /D ₇	V ₇	m ₇	D ₈				2	24	
"	13	•	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃ /m ₂	m ₃	V ₃	m ₄	D ₄	m ₅	V ₄	D ₅	V ₅	m ₆	D ₆	V ₆						6	24	
"	14	•	D ₁	V ₁	D ₂	V ₂ /m ₁	D ₃	m ₂	m ₃	V ₃ /D ₄	m ₄	D ₅	m ₅	m ₆	V ₄	D ₆	m ₇	V ₅	m ₈						3	22	
"	16		D ₁ •	V ₁	D ₂	V ₂	D ₃	m ₁	D ₄	m ₂	V ₃	m ₃	D ₅	v ₄	m ₄	V ₅	D ₆	V ₆ /m ₅	V ₇	m ₆					6	25	
E	3	•	/D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	V ₃ /m ₂	D ₄	m ₃	v ₄	m ₄												3	15	
"	7	•	D ₁	V ₁	D ₂	V ₂	m ₁	m ₂	V ₃	m ₃	D ₃	m ₄	v ₄ ?	D ₄	m ₅	V ₅ ?	m ₆								7	22	
"	13	•	D ₁	V ₁	D ₂	D ₃	V ₂	m ₁	m ₂	D ₄	m ₃	V ₃	D ₅	V ₄	m ₄	D ₆	V ₅	m ₅							4	20	
"	15		D ₁ •	D ₂	V ₁	D ₃	m ₁	V ₂	D ₄	m ₂	V ₃ /D ₅	v ₄ ?	m ₃	m ₄	←												13
"	17	•	/D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	V ₃ /m ₂	D ₄	m ₃	m ₄	V ₄	D ₅	V ₅	m ₅	m ₆	v ₆	V ₇	m ₇ /d ₆	m ₈				3	24	
"	20	•	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	D ₄	m ₂	V ₃	m ₃	D ₅	v ₄ ?	m ₄ /D ₆	←											14
"	21	•	/D ₁	V ₁	D ₂	D ₃	m ₁	V ₂	D ₄	m ₂	v ₃	D ₅	V ₄	m ₃	D ₆	V ₅	m ₄	m ₅	V ₆	D ₇ ?	m ₆	V ₇			3	23	
"	22	•	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	D ₄	m ₂	m ₃	V ₃	D ₅	v ₄	m ₄	m ₅	D ₆								5	20	
"	29	•	/D ₁	V ₁	D ₂	v ₂	m ₁	D ₃	V ₃	m ₂	D ₄	m ₃	v ₄ /m ₄	V ₅	D ₅	V ₆	m ₅	D ₆ ?	V ₇	m ₆	m ₇	V ₈			5	26	
"	30	•	/D ₁	D ₂	V ₁	D ₃	V ₂	D ₄ /m ₁	V ₃	m ₂	D ₅	m ₃	m ₄	v ₄ ?											7	20	
"	33	•	D ₁	V ₁	D ₂	m ₁	V ₂	D ₃	m ₂	V ₃	m ₃	D ₄	m ₄	v ₄ ?	m ₅	m ₆	V ₅	D ₅	m ₇	v ₆ ?	V ₇	D ₆ ?	←				20
"	34	•	/D ₁	V ₁	D ₂	V ₂ /D ₃	m ₁	D ₄	m ₂	V ₃	m ₃	D ₅	v ₄ ?	m ₄	m ₅	V ₅	v ₆	m ₆	m ₇	m ₈	V ₇ ?				4	24	
"	36	•	/D ₁	V ₁	D ₂	V ₂ /m ₁	D ₃	m ₂	m ₃	m ₄	V ₃	D ₄	m ₅	m ₆	v ₄ ?	m ₇	V ₅	m ₈	m ₉	D ₅	V ₆	m ₁₀			2	23	
"	40	•	/D ₁	V ₁	D ₂	D ₃	m ₁	V ₂ /m ₂	D ₄	m ₃	v ₃ /m ₄	D ₅	V ₄	m ₅											5	19	
"	45	•	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	m ₂	V ₃	m ₃	D ₄	m ₄	v ₄	m ₅	m ₆	m ₇	D ₅	m ₈						2	19	
"	53	•	D ₁	V ₁	D ₂	D ₃	V ₂	m ₁	D ₄	m ₂	D ₅ /m ₃	V ₃	m ₄	D ₆	v ₄	m ₅	m ₆	V ₅	m ₇	D ₇					6	25	
"	56	•	/D ₁	V ₁	D ₂	V ₂	D ₃	m ₁ /D ₄	m ₂	D ₅	V ₃	D ₆ /m ₃	V ₄	m ₄	V ₅	D ₇	m ₅	m ₆	v ₆	V ₇	m ₇	m ₈	m ₉	V ₈	←		24

← = Bifurcation of
Lobar Stem Bronchus.

• = Site of origin of the lobar bronchus of
intermediate lobe

CHART IV BRONCHIAL TREE OF DOG

- Branches of the Lobar Stem Bronchus of INTERMEDIATE LOBE
(32 Specimens)

Numerical Order of Branches.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
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Specimen		Numerical Order of Branches.																											Additional Branches	Total No of Branches				
No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27						
7	1	D_1^+	m_1	V_1^+	D_2	m_2	D_3	V_2	m_3	m_4	D_4	V_3	D_5/m_5	V_4	D_6	V_5	D_7	m_6													3	21		
"	2	m_1	D_1^+	V_1	D_2	m_2	D_3	V_2	m_3	D_4	m_4	m_5	V_3	D_5	m_6	V_4/D_6	m_7	V_5	D_7	V_6												20		
"	3	m_1	D_1^+	m_2	V_1^+	D_2	m_3	m_4	D_3	V_2	m_5	m_6/D_4	V_3	D_5	m_7	D_6	m_8	V_4/D_7	m_9	V_5	D_8											22		
"	4	D_1^+	m_1	V_1	d_2	V_2^+	m_2	D_3	m_3	V_3	l_1	D_4	m_4	\leftarrow																		12		
"	5	D_1^+	m_1	D_2/V_1	m_2/V_2	m_3	D_3	m_4	V_3	d_4/V_4	m_5	D_5	m_6	m_7	V_5	m_8	D_6	m_9	\leftarrow													20		
"	6	D_1^+	m_1	m_2	V_1	D_2	V_2	m_3	D_3	m_4	l_1	d_4/V_3	m_5	D_5	m_6	m_7/m_8	D_6/V_4	m_9	V_5	D_7	V_6	\leftarrow										23		
"	7	D_1^+	m_1	V_1	D_2	V_2^+	D_3	m_2	D_4	V_3	m_3	l_1	\leftarrow																			11		
"	8	m_1	D_1^+	m_2	D_2	V_1^+	m_3	D_3	V_2/m_4	D_4/m_5	l_1	d_5	V_3/l_2	m_6	D_6	V_4	m_7	D_7	V_5	d_8	D_9	m_8	V_6									3	28	
"	9	D_1^+	m_1	d_2	V_1^+	m_2	D_3	m_3/m_4	V_2	D_4	V_3/m_5	d_5	m_6/D_6	V_4	D_7/m_7	m_8	V_5	m_9	V_6														22	
"	10	D_1^+	m_1	V_1	D_2	m_2	D_3/V_2^+	m_3	D_4	m_4	V_3	D_5	m_5	m_6	V_4	D_6/m_7	l_1	m_8	l_2	D_7	V_5	m_9										23		
"	11	m_1	D_1^+	V_1	m_2	D_2	V_2	D_3^+	V_3	m_3	m_4	V_4	d_4	V_5/m_5	d_5	l_1	d_6	m_6	\leftarrow														18	
"	14	m_1	D_1^+	m_2	V_1^+	D_2	m_3	D_3	V_2	m_4	D_4	V_3	V_4/D_5	m_5	D_6	m_6																	16	
"	16	D_1^+	m_1	V_1	D_2	V_2/m_2	D_3	m_3	m_4/V_3	D_4/m_5	V_4/D_5	m_6	V_5	D_6	l_1	\leftarrow																	18	
E	3	l_1	D_1^+	m_1	V_1	D_2	V_2^+	m_2	m_3	D_3	m_4	V_3	D_4	m_5	D_5/V_4	m_6																	5	21
"	7	m_1	D_1^+	m_2	V_1	D_2	m_3	V_2	D_3	m_4	m_5	V_3	D_4	m_6	V_4																		4	18
"	13	D_1^+	m_1	V_1	D_2	m_2	D_3/V_2	m_3	D_4	m_4	D_5	V_3	m_5	D_6																			4	18
"	15	D_1^+	m_1	m_2	V_1	D_2	m_3	V_2	D_3	m_4	V_3	m_5	l_1	m_6	D_4	V_4	D_5^+	V_5															5	22
"	17	D_1^+	m_1	D_2	V_1	D_3/m_2	V_2	D_4	V_3	m_3	D_5	m_4/D_6	V_4	m_5	D_7	V_5	D_8																18	
"	20	m_1	D_1^+	m_2	V_1	D_2	m_3	V_2	D_3	m_4	D_4	V_3	m_5	V_4	D_5	V_5	D_6	m_6	V_6	\leftarrow													18	
"	21	m_1	d_1	D_2^+	V_1/m_2	D_3	V_2	m_3	D_4	m_4	V_3	D_5	m_5	V_4	D_6	m_6	D_7/V_5	m_7	V_6	D_8	m_8												3	25
"	22	D_1^+	m_1	D_2	V_1^+	m_2	D_3	m_3	D_4	m_4	m_5	V_2/D_5	m_6	D_6	V_3	m_7	D_7	m_8	D_8	V_4	D_9	m_9	D_{10}	m_{10}									1	25
"	29	m_1	m_2	D_1^+	m_3	V_1	V_2/D_2	m_4	V_3	D_3	m_5	D_4	m_6	V_4	D_5	V_5	m_7	D_6	D_7	V_6													20	
"	30	D_1^+	m_1	m_2	V_1	\leftarrow																											4	
"	33	D_1^+	m_1	V_1^+	D_2	m_2	D_3	V_2	m_3/l_1	m_4	D_4	V_3^+	m_5	D_5/m_6	m_7	D_6	V_4	m_8	V_5	d_7	m_9	\leftarrow											22	
"	36	m_1	D_1^+	m_2	V_1	D_2	m_3/V_2	m_4/D_3	V_3	m_5	V_4	\leftarrow																					12	
"	40	D_1^+	m_1	m_2	V_1/D_2	m_3	V_2/D_3	m_4	m_5	D_4	V_3/m_6	V_4	D_5/m_7	l_1	\leftarrow																		17	
"	45	D_1^+	m_1	D_2	m_2	D_3/V_1^+	m_3	D_4	m_4	m_5	V_2	D_5	m_6	V_3/D_6	V_4	m_7	D_7	m_8	D_8/m_9	l_1	m_{10}	V_5											8	32
"	52	D_1^+	m_1	D_2	V_1	l_1	V_2^+	m_2	D_3	m_3/m_4	D_4	m_5	V_3	D_5	m_6	V_4	D_6	m_7	d_7	m_8	l_2	D_8											6	28
"	53	D_1^+	m_1	V_1^+	D_2	m_2	D_3	m_3	m_4	V_2	d_4	m_5	V_3/D_5	m_6	\leftarrow																		14	
"	54	D_1^+	m_1	V_1	D_2	V_2/m_2	V_3/D_3	m_3	D_4	m_4	m_5	D_5	m_6	V_4	D_6	m_7	V_5	D_7/m_8	\leftarrow														20	
"	55	D_1^+	m_1	D_2/V_1^+	m_2	D_3	V_2	m_3	D_4	m_4	V_3	D_5	m_5	D_6	V_4	m_6	D_7	m_7	V_5	D_8	m_8	V_6	m_9	D_9	V_7	D_{10}/m_{10}						3	30	
"	56	m_1	D_1^+	m_2	V_1	D_2^+	m_3	V_2	D_3	m_4	V_3/m_5	D_4	m_6	D_5	m_7																		7	22

Y = Bifurcation of
Lobar Stem Bronchus

CHART V BRONCHIAL TREE OF DOG,

- Branches of Lobar Stem Bronchus of LEFT APICAL LOBE
(33 Specimens)

- Branches of Lobar Stern Branchus of <u>LEFT APICAL LOBE</u>																																		
(33 Specimens)																																		
Specimen	No.	Numerical Order of Branches:-																													Additional Branches.	Total No. of Branches.		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29				
M	1	D ₁	V ₁	D ₂ /V ₂	V ₃ /d ₃	v ₄ /D ₄	v ₅	←																										
"	2	D ₁	V ₁	d ₂ /V ₂	D ₃	v ₃	V ₄	D ₄	l ₁	D ₅	m ₁	V ₅	D ₆	V ₆	D ₇	V ₇	D ₈ /V ₈	←																
"	3	D ₁	V ₁	D ₂ ⁺ /l ₁	V ₂	d ₃ /l ₂	D ₄	V ₃	m ₁	D ₅	V ₄	D ₆	V ₅	d ₇	v ₆	d ₈	V ₇	D ₉																
"	4	D ₁	D ₂ ⁺ /V ₁	V ₂ ⁺	d ₃	m ₁	d ₄ /v ₃	D ₅ ⁺	m ₂	V ₄	d ₆	m ₃	V ₅	d ₇	m ₄	d ₈	V ₆	d ₉	m ₅	D ₁₀	V ₇	m ₆	←											
"	5	D ₁	V ₁	D ₂	V ₂	D ₃	v ₃	d ₄ /V ₄	m ₁	D ₅ /v ₅	m ₂ /V ₆	D ₆	V ₇	m ₃	V ₈	D ₇	V ₉	←																
"	6	D ₁	V ₁	D ₂ ⁺	l ₁	V ₂	m ₁ /l ₂	v ₃	l ₃ /D ₃	V ₄	l ₄	D ₄	D ₅	l ₅	D ₆	V ₅	l ₆ /m ₂	V ₆	D ₇	m ₃	l ₇	D ₈												
"	7	D ₁	V ₁ ⁺	D ₂	l ₁	v ₂	d ₃	D ₄	v ₃	m ₁	v ₄ /D ₅	←																						
"	8	D ₁	V ₁ ⁺	D ₂	l ₁	d ₃	V ₂	m ₁ /l ₂	D ₄	v ₃	m ₂	V ₄	m ₃	D ₅	V ₅	m ₄ /V ₆	l ₃	D ₆	←															
"	9	D ₁	V ₁	D ₂	V ₂	D ₃	V ₃	l ₁	D ₄	V ₄	D ₅	m ₁	V ₅	D ₆	m ₂	V ₆	d ₇	V ₇ /D ₈	m ₃	d ₉	V ₈	D ₁₀	l ₂	m ₄	D ₁₁ /V ₉	l ₃	v ₁₀	l ₄						
"	10	D ₁	V ₁ ⁺	D ₂	l ₁	D ₃	l ₂ /m ₁	D ₄	m ₂	V ₂	m ₃	V ₃	D ₅	D ₆	V ₄	m ₄	V ₅	m ₅	l ₃	D ₇	m ₆	V ₆	m ₇	D ₈ /V ₇	D ₉ /V ₈									
"	11	D ₁	V ₁ /D ₂	V ₂	D ₃ ⁺	V ₃	m ₁	V ₄	d ₄	m ₂	v ₅	m ₃	d ₅ /V ₆	m ₄	l ₁	m ₅	←																	
"	13	D ₁	V ₁	D ₂	V ₂	V ₃	D ₃	m ₁	V ₄	d ₄	V ₅	m ₂	m ₃	D ₅	V ₆	D ₆	V ₇	D ₇ /V ₈	D ₈	m ₄	D ₉ ⁺													
"	14	D ₁	V ₁	D ₂	l ₁	V ₂	d ₃	V ₃	D ₄	l ₂	V ₄	D ₅	l ₃	D ₆	D ₇	V ₅	m ₁	V ₆	D ₈	V ₇	D ₉	D ₁₀	V ₈											
"	16	D ₁	V ₁ ⁺	D ₂	l ₁	D ₃ /l ₂	l ₃ /D ₄	D ₅ /m ₁	m ₂	l ₄	D ₆	m ₃	m ₄ /l ₅	D ₇	v ₂	D ₈																		
E	3	D ₁	V ₁ /D ₂	V ₂	D ₃	V ₃	D ₄	m ₁	V ₄	D ₅	V ₅	m ₂	d ₆	m ₃	v ₆	←																		
"	4	D ₁	V ₁	D ₂	V ₂	D ₃	V ₃	D ₄ ⁺	V ₄	m ₁	d ₅ /V ₅	d ₆	v ₆	D ₇	m ₂	V ₇	d ₈ ⁺	m ₃ ⁺	l ₁	←														
"	7	D ₁	V ₁	D ₂ ⁺	V ₂	V ₃	d ₃	m ₁	V ₄	m ₂	V ₅	D ₄	m ₃	l ₁	m ₄	D ₅	V ₆	V ₇ /l ₂	D ₆	V ₈	d ₇	V ₉	m ₅	D ₈	l ₃	m ₆								
"	13	D ₁ ⁺	V ₁	d ₂	V ₂	D ₃ ⁺	V ₃	d ₄	V ₄	d ₅	m ₁	V ₅	d ₆ ⁺	m ₂	l ₁	m ₃	V ₆																	
"	20	D ₁	V ₁	V ₂	D ₂	V ₃	D ₃	V ₄	m ₁	d ₄	V ₅	←																						
"	21	D ₁	D ₂	V ₁	V ₂	D ₃	V ₃	D ₄	V ₄	d ₅	V ₅	D ₆	m ₁	l ₁	V ₆	d ₇	V ₇	m ₂	←															
"	22	D ₁	V ₁	D ₂	V ₂	l ₁	m ₁	V ₃ ⁺	D ₃ ⁺	l ₂	m ₂	d ₄ /V ₄	m ₃	m ₄	d ₅	V ₅	D ₆	m ₅	V ₆															
"	29	D ₁	V ₁	D ₂	V ₂	D ₃	V ₃	l ₁	m ₁	v ₄	D ₄	V ₅ ⁺	m ₂	D ₅	v ₆	m ₃	D ₆	l ₂	m ₄	m ₅	D ₇	V ₇	V ₈	D ₈										
"	30	D ₁	D ₂	V ₁	D ₃	d ₄	V ₂	D ₅	V ₃	l ₁ /m ₁	V ₄ /D ₆	v ₅ /m ₂	V ₆	d ₇	l ₂	D ₈	V ₇	V ₈	D ₉	D ₁₀	V ₉	m ₃												
"	33	D ₁	V ₁	V ₂	D ₂	D ₃	V ₃	m ₁ /V ₄	l ₁ /m ₂	D ₄ ⁺	V ₅	m ₃	l ₂	V ₆	m ₄	d ₅	V ₇	m ₅	l ₃	v ₈	m ₆	d ₆	←											
"	34	D ₁	V ₁ ⁺	D ₂	l ₁	D ₃	v ₂	m ₁	l ₂ /D ₄	V ₃	D ₅	m ₂	v ₄	D ₆	V ₅	D ₇	V ₆	D ₈	l ₃	v ₇	D ₉	V ₈	D ₁₀	l ₄	V ₉	D ₁₁	V ₁₀	←						
"	36	D ₁	V ₁	D ₂	V ₂	D ₃	V ₃	m ₁	D ₄ /V ₄	m ₂	l ₁	←																						
"	40	D ₁	V ₁	D ₂	V ₂	D ₃	V ₃	m ₁	l ₁	D ₄ /V ₄	m ₂	l ₂	V ₅	m ₃	D ₅ ⁺	l ₃	m ₄	V ₆	d ₆	m ₅	v ₇	D ₇ ⁺	l ₄	m ₆	l ₅	V ₈	d ₈	m ₇	l ₆	←				
"	45	D ₁	V ₁	V ₂	D ₂ ⁺	V ₃	V ₄	d ₃	v ₅	m ₁	V ₆	D ₄	m ₂ /l ₁	V ₇	D ₅	m ₃	V ₈	m ₄	l ₂	v ₉	D ₆	V ₁₀	l ₃ /m ₅											
"	52	D ₁	D ₂ ⁺	V ₁	V ₂ ⁺	d ₃	l ₁	d ₄	v ₃	d ₅ /v ₄	D ₆ ⁺	V ₅	m ₁	l ₂	V ₆	m ₂	l ₃	v ₇	d ₇	V ₈	l ₄	m ₃												
"	53	D ₁	V ₁	D ₂	V ₂	d ₃	V ₃	D ₄ ⁺	V ₄	m ₁	d ₅	V ₅	D ₆	m ₂	V ₆	D ₇	v ₇	D ₈	V ₈	D ₉	m ₃	←												
"	54	D ₁	d ₂ /V ₁	D ₃	v ₂	D ₄ /V ₃	l ₁	D ₅	←																									
"	55	D ₁	V ₁	d ₂	V ₂	D ₃ ⁺	l ₁	V ₃	m ₁	V ₄	d ₄	D ₅	m ₂	V ₅	l ₂	m ₃	D ₆	V ₆																
"	56	D ₁	V ₁ ⁺	D ₂	l ₁	D ₃ /V ₂	V ₃	V ₄	d ₄	V ₅	D ₅	V ₆	d ₆	D ₇ /m ₁	V ₇	D ₈ /V ₈	V ₉	m ₂	←															

← = Bifurcation of Lobar Stem Bronchus.

CHART VI BRONCHIAL TREE OF DOG

- Branches of Lobar Stem Bronchus of LEFT CARDIAC LOBE
(33 Specimens).

Specimen No.	Numerical Order of Branches																				Additional Branches.	Total No of Branches
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
M 1	P ₁	A ₁	P ₂	a ₂	A ₃ ⁺	P ₃	m ₁	P ₄	a ₄	P ₅	m ₂	a ₅	m ₃	P ₆	a ₆	P ₇	l ₁	m ₄	A ₇	P ₈	2	22
" 2	P ₁	A ₁	P ₂	A ₂	P ₃	m ₁	A ₃	P ₄	m ₂	A ₄ /P ₅	m ₃ /A ₅	P ₆	A ₆	m ₄	A ₇	h ₇					2	20
" 3	P ₁	A ₁ ⁺	P ₂	a ₂	P ₃	A ₃ ⁺	P ₄ /m ₁	l ₁	m ₂	A ₄	P ₅										3	15
" 4	P ₁	A ₁	m ₁	A ₂ ⁺	P ₂	m ₂	a ₃	P ₃	m ₃	a ₄	m ₄	P ₄	a ₅	l ₁	m ₅	P ₅	m ₆	l ₂	A ₆		3	22
" 5	P ₁	A ₁ ⁺	P ₂	A ₂ ⁺	P ₃	m ₁	a ₃	m ₂	P ₄	a ₄	m ₃	A ₅	P ₅	m ₄	l ₁	m ₅ /a ₆	P ₆				4	22
" 6	P ₁	A ₁ ⁺	P ₂	a ₂	P ₃	A ₃ ⁺	m ₁	P ₄	l ₁	m ₂	P ₅	a ₄	A ₅	m ₃	P ₆	l ₂	m ₄	P ₇	<			18
" 7	P ₁	A ₁ ⁺ /P ₂	P ₃ ⁺	a ₂	m ₁	l ₁	A ₃ ⁺	m ₂	P ₄	m ₃	a ₄	A ₅	m ₄	P ₅							2	17
" 8	P ₁	A ₁ ⁺	P ₂	a ₂	P ₃	m ₁	a ₃	A ₄ ⁺	P ₄	m ₂	l ₁ /P ₅	m ₃	P ₆	l ₂	m ₄ /P ₇	a ₅	l ₃	m ₅	<			20
" 9	P ₁	A ₁ ⁺	P ₂	m ₁	a ₂	P ₃	a ₃	m ₂	P ₄	A ₄	P ₅	m ₃	A ₅	P ₆	m ₄	a ₆	P ₇				3	20
" 10	P ₁	A ₁ ⁺	P ₂	a ₂	P ₃	A ₃ ⁺	m ₁	P ₄	l ₁	m ₂	P ₅	l ₂	m ₃	m ₄ /l ₃	a ₄	l ₄	m ₅				2	20
" 11	P ₁	A ₁	P ₂	A ₂ ⁺	P ₃	m ₁	P ₄	l ₁	m ₂	l ₂	P ₅ /a ₃	l ₃	m ₃	l ₄	<							15
" 13	P ₁	A ₁	P ₂	A ₂ ⁺	P ₃	m ₁	a ₃	P ₄	m ₂	P ₅ ⁺ /a ₄	A ₅	m ₃	l ₁	m ₄	A ₆	h ₆					2	19
" 14	P ₁	A ₁ ⁺	P ₂	a ₂	P ₃	A ₃ ⁺	m ₁	P ₄	a ₄	P ₅	m ₂ /l ₁	<										12
" 16	P ₁	A ₁	P ₂	P ₃	A ₂	m ₁	P ₄	a ₃	m ₂	l ₁												10
E 4	P ₁	A ₁	P ₂	A ₂ ⁺	m ₁	P ₃	m ₂	P ₄ ⁺	a ₃	m ₃	A ₄	l ₁	m ₄	l ₂	A ₅ ⁺						2	17
" 7	P ₁	A ₁	P ₂	a ₂	A ₃ ⁺	P ₃	m ₁	P ₄	a ₄	m ₂	P ₅	a ₅	P ₆	m ₃	a ₆	m ₄	l ₁	P ₇	m ₅	l ₂	<	20
" 13	P ₁	A ₁ ⁺	P ₂	m ₁	a ₂	P ₃	a ₃	m ₂	P ₄	a ₄ ⁺	A ₅	m ₃	P ₅								7	20
" 17	P ₁	A ₁ ⁺	P ₂	m ₁ /P ₃	a ₂	A ₃ ⁺	P ₄ /m ₂	a ₄ ⁺	P ₅	m ₃												12
" 20	P ₁	A ₁	P ₂	a ₂	A ₃ ⁺	P ₃ /m ₁	l ₁	P ₄	m ₂	l ₂	m ₃	m ₄									9	22
" 21	P ₁	A ₁	P ₂	A ₂ ⁺	P ₃ /m ₁	a ₃	P ₄	m ₂	a ₄ /P ₅	m ₃	<											12
" 22	P ₁	A ₁	P ₂	A ₂ ⁺	P ₃	a ₃	P ₄ ⁺	m ₁	l ₁	A ₄	m ₂ /l ₂	m ₃ /l ₃	A ₅	m ₄	l ₄	m ₅					2	20
" 29	P ₁	A ₁	m ₁	A ₂	P ₂	a ₃ /m ₂	P ₃	A ₄ ⁺	m ₃	P ₄	a ₅	P ₅	m ₄	<								14
" 30	P ₁	A ₁	m ₁	A ₂ ⁺	P ₂	m ₂	P ₃ /a ₃	m ₃	a ₄	P ₄	m ₄	A ₅ ⁺	m ₅	P ₅	P ₆	a ₆	m ₆	a ₇			4	23
" 33	P ₁	A ₁ ⁺	P ₂	a ₂	P ₃	A ₃ ⁺	m ₁	P ₄	a ₄	m ₂	P ₅	a ₅	m ₃	P ₆							5	19
" 34	P ₁	A ₁ ⁺	P ₂	l ₁	P ₃	m ₁	P ₄ ⁺	l ₂	m ₂	A ₂	l ₃	m ₃										12
" 36	P ₁	A ₁ ⁺	P ₂	m ₁ /P ₃	a ₂	m ₂	P ₄ ⁺	a ₃	m ₃	A ₄ ⁺											12	23
" 40	P ₁	A ₁	P ₂ /A ₂ ⁺	P ₃	m ₁	a ₃	P ₄	m ₂	P ₅	a ₄	m ₃	<										12
" 45	P ₁	A ₁	m ₁	A ₂ ⁺	P ₂	m ₂	a ₃	P ₃	m ₃	a ₄	P ₄	m ₄	a ₅	<								13
" 52	P ₁	A ₁	P ₂	A ₂ ⁺	m ₁	P ₃	m ₂	a ₃	m ₃	<												9
" 53	P ₁	A ₁	P ₂	a ₂	P ₃	A ₃ ⁺	m ₁	P ₄	a ₄	m ₂	m ₃	a ₅	P ₅	m ₄	a ₆	P ₆	m ₅	l ₁	m ₆	A ₇	4	24
" 54	P ₁	A ₁ ⁺	P ₂	a ₂ /m ₁	m ₂	P ₃	a ₃	m ₃	P ₄	A ₄	m ₄	A ₅	P ₅	m ₅							3	18
" 55	P ₁	A ₁	P ₂	A ₂ ⁺	P ₃	P ₄ /m ₁	a ₃	m ₂	P ₅	a ₄	a ₅	m ₃	<									13
" 56	P ₁	A ₁	P ₂	a ₂	h ₃	A ₃ ⁺	m ₁	P ₄	a ₄	m ₂	P ₅ ⁺	m ₃	A ₅	m ₄	A ₆	m ₅					3	19

< = Bifurcation of Lobar Stem Bronchus.

CHART VII BRONCHIAL TREE OF DOG

-Branches of Lobar Stem Branchus of LEFT DIAPHRAGMATIC LOBE
(33 Specimens).

-Branches of Lobar Stem Branchus of LEFT DIAPHRAGM.																										
(33 Specimens).																										
Specimen No.	Numerical Order of Branches:-																							Additional Branches.	Total No of Branches.	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23			
M 1	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	m ₂	m ₃	D ₄	v ₃	m ₄	V ₄ /D ₅	m ₅	D ₆	m ₆	m ₇	v ₅	D ₇	v ₆					6	26	
" 2	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	D ₄	V ₃	m ₂	D ₅	m ₃	m ₄	m ₅	D ₆	m ₆ /v ₄	D ₇	m ₇	V ₅	D ₈	m ₈	m ₉			2 <	24	
" 3	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃	m ₂	m ₃	v ₄	D ₄	m ₄	V ₅	m ₅	m ₆	D ₅								5	21	
" 4	D ₁	V ₁	D ₂	V ₂	m ₁ /D ₃	v ₃	m ₂	m ₃	D ₄	V ₄	m ₄	D ₅	<													13
" 5	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃	m ₂	V ₄ /m ₃	D ₄	m ₄	D ₅	v ₅	m ₅	v ₆	<										16
" 6	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	v ₃ /D ₄	v ₄ /m ₂ /m ₃	D ₅	V ₅	m ₄	D ₆	m ₅	m ₆	v ₆ ?/m ₇ /D ₇ ?/v ₇ ?/m ₈ ? <										22	
" 7	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	v ₃	D ₄	V ₄	m ₂	D ₅	<														11
" 8	D ₁	V ₁	D ₂	V ₂ /m ₁	D ₃ /m ₂	v ₃	m ₃	V ₄	m ₄	D ₄	m ₅	v ₅	D ₅	m ₆										6	22	
" 9	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	v ₃	D ₄	m ₂ /m ₃	V ₄	D ₅	m ₄	v ₅ /D ₆	m ₅	D ₇	V ₆	m ₆	D ₈	m ₇ /V ₇					3 <	25	
" 10	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	D ₄	m ₂	m ₃	v ₃	D ₅	m ₄	V ₄	m ₅	D ₆	v ₅	D ₇	m ₆	m ₇					3 <	22	
" 11	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	D ₄ /m ₂	V ₃	D ₅	m ₃	v ₄	m ₄	D ₆	v ₅	<											15
" 13	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	v ₃	D ₄	v ₄	m ₂ /D ₅	V ₅	m ₃	D ₆	v ₆	m ₄ /v ₇ /m ₅									4	22	
" 14	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃ /m ₂	m ₃	D ₄ /v ₄	m ₄	V ₅	D ₅	m ₅	V ₆	D ₆	m ₆	V ₇	m ₇ /D ₇						2	23	
" 16	D ₁	V ₁	D ₂	V ₂	D ₃ /m ₁	v ₃	D ₄	v ₄ /m ₂	V ₅	D ₅	m ₃ /v ₆													5	19	
E 3	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	m ₂	D ₄ /v ₃	m ₃	V ₄	m ₄ /D ₅	D ₆	m ₅	m ₆	m ₇	m ₈										18
" 4	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	m ₂	v ₃	D ₄	V ₄	m ₃	D ₅	m ₄	V ₅	D ₆	m ₅	m ₆	V ₆ ?/D ₇ ?/m ₇ ?/m ₈						2	23	
" 7	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃	m ₂	m ₃	D ₄	V ₄ /m ₄	D ₅	m ₅	m ₆										4	19	
" 13	D ₁	V ₁	D ₂	m ₁	V ₂	D ₃	m ₂	v ₃	D ₄	m ₃	V ₄	m ₄	D ₅	m ₅	D ₆	v ₅								6	22	
" 15	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃ ?/m ₂	V ₄ ?	D ₄	m ₃ /D ₅	v ₅	m ₄	m ₅	v ₆ ?/m ₆	m ₇									3	21	
" 17	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	D ₄ /m ₂	V ₃	m ₃	D ₅	v ₄	m ₄	D ₆	m ₅	<											15
" 20	D ₁	V ₁	D ₂	m ₁	V ₂	m ₂	D ₃	v ₃	m ₃	m ₄ /m ₅	v ₄	m ₆ /D ₄	V ₅	m ₇ ? <												16
" 21	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	m ₂	v ₃	D ₄	m ₃	v ₄ /m ₄	D ₅	m ₅	m ₆	<											15
" 22	D ₁	V ₁	V ₂	D ₂	D ₃	v ₃ ?/m ₁	V ₄	D ₄	m ₂	D ₅	v ₅	m ₃												2	15	
" 29	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃	m ₂	D ₄	v ₄ /m ₃	m ₄	D ₅	m ₅	V ₅	D ₆	m ₆	v ₆ ?/m ₇ /D ₇	v ₇	m ₈	m ₉	<				23	
" 30	D ₁	V ₁	D ₂	V ₂	D ₃	D ₄	V ₃	m ₁	D ₅	m ₂	v ₄	m ₃	v ₅ ?/m ₄													14
" 33	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	V ₃ /D ₄	m ₂	D ₅	v ₄	m ₃	D ₆ /m ₄	v ₅	m ₅	<											16
" 34	D ₁	V ₁	D ₂	V ₂	D ₃ /m ₁	D ₄	V ₃	m ₂	D ₅	v ₄ ?/m ₃	<															12
" 36	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	v ₃	m ₂	m ₃	V ₄ /m ₄	D ₄	m ₅	v ₅	m ₆										3	18	
" 40	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃	v ₃	m ₂	m ₃	v ₄	m ₄ /D ₄	V ₅	D ₅	m ₅	v ₆	m ₆	<									17
" 45	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	v ₃ /D ₄	m ₂	v ₄	V ₅	m ₃	D ₅	m ₄	v ₆	m ₅	m ₆	v ₇ ?/m ₇	v ₈ ?/m ₈	D ₆	m ₉	<				23	
" 53	D ₁	V ₁	D ₂	V ₂	V ₃	D ₃ /m ₁	D ₄ /m ₂	v ₄ ?/m ₃	m ₄	V ₅	D ₅	m ₅	m ₆	m ₇ ?/D ₆										5	23	
" 54	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁ /v ₃	m ₂	m ₃	V ₄	D ₄	m ₄	D ₅ ?/m ₅	m ₆	m ₇	D ₆ ?/m ₈	<										18
" 56	D ₁	V ₁	D ₂	V ₂	m ₁	D ₃ /m ₂	v ₃	V ₄ /m ₃	D ₄ /m ₄	v ₅ ?/m ₅	m ₆													15	30	

< = Bifurcation of
Lobar Stem Branchus.

Table 4
NUMBER OF BRANCHES OF THE LOBAR STEM BRONCHI

Lobe	Total No. of Branches*		M A I N S E R I E S				A C C E S S O R Y B R O N C H I											
			Dorsal Series		Ventral Series		'm' Branches		'l' Branches									
	Min.	Max.	Aver- age	Min.	Max.	Aver- age	Min.	Max.	Aver- age	Min.	Max.	Aver- age						
Right Apical	6	30	20	2	8	5.4	3	9	6.54	0	8	3.54	0	5	2.2			
Left Apical	9	31	21	4	11	7.2	2	10	7.0	0	7	3.2	0	7	2.0			
Right Diaphrag- matic	13	26	21	4	8	5.7	4	8	5.6	4	10	6.4	0	0	0			
Left Diaphrag- matic	11	23	19	4	8	5.7	4	8	5.3	2	9	6.0	0	0	0			
Intermediate	4	32	20	1	10	6.06	1	7	4.62	2	10	6.93	0	2	0.5			
Right Cardiac	4	26	19	2	9	5.1	Caudal Series									0	7	1.79
Left Cardiac	9	24	17.5	2	7	4.8	3	8	5.2	2	6	3.9	0	4	1.09			

* Figures in this column have been worked out from the "Total No. of Branches" shown in Charts I to VII, and include the approximate number of "Additional branches" indicated in the same charts.

A REVIEW OF THE CURRENT CONCEPTS OF THE BRONCHOPULMONARY SEGMENTS - With a View to Determine Criteria for the Bronchopulmonary Segments in Dog

Some definite criteria must be predetermined on the basis of which the broncho-pulmonary segments may be established. It is necessary for this reason to survey the current views on the broncho-pulmonary segment and then determine the criteria in the light of this survey.

Several authors have given a variety of definitions and descriptions of the broncho-pulmonary segment.

Ewart (1889) was the first to conceive what he called the "respiratory district". In his monograph he writes, "Within each lobe, large groups of lobules being served by separate bronchi are thus kept in practical isolation from each other as regard their air supply. Each of these sublobar groups may be considered as forming a *separate respiratory district*....."

Kramer and Glass (1932) called Ewart's "respiratory district" a "broncho-pulmonary segment", and they stated that, "..... the broncho-pulmonary segment is a subdivision of a pulmonary lobe. Each segment occupies a definite constant position in the pulmonary architecture and thoracic cavity and is supplied by a constantly placed bronchus, whose orifice is situated in a large lobar bronchus and easily visible to the bronchoscopist."

Ten years later, Adams and Davenport (1942) redefined the broncho-pulmonary segment as a "subdivision of pulmonary lobe delimited by avascular diverging planes which may or may not be indicated by complete or partial fissures. Its apex lies in the hilus and its base fills an area of the lung periphery." They also stated that these planes of avascular tissue are

"uncrossed by bronchi or blood vessels beyond the hilus".

Jackson and Huber (1943) stated that in its simplest conception a broncho-pulmonary segment is "the area of distribution of any bronchus". According to them, "it is a mistake to have too rigid a conception of the broncho-pulmonary segment because the lung is really divided into smaller and smaller segments each respectively the area of distribution of a certain bronchus. The largest segments into which each lobe divides according to bronchial distribution are, we believe, of the greatest clinical importance."

The next definition came from Foster-Carter and Hoyle (1945), who defined the broncho-pulmonary segment as "the portion of lung served by a principal branch of a lobar bronchus, and this branch may then be called a segmental bronchus. Such branches are large and relatively constant..... Although there can be variety in the shape and size of the segments in different subjects, there is a characteristic pattern, which is common to all."

In the same year Appleton (1945) described the broncho-pulmonary segment in the following words: "The term broncho-pulmonary segment has been restricted arbitrarily to those relatively large portions of the lung which are ventilated by bronchi that have orifices in one of the lobar bronchi. These segments can be isolated from their neighbours by dissection with varying degrees of ease, since there are planes of connective tissue which will be here distinguished as the 'intersegmental planes'. Tributaries of pulmonary vein lie in these planes and receive veins from the contiguous segments."

Another definition was given by Boyden (1945) who defined the broncho-pulmonary segment as "the zone of distribution of a major bronchus which may or may not be entered by arteries from adjacent segments and which is drained peripherally by veins occupying intersegmental planes."

Later Hardie-Neil and Gilmour (1946), referring to the drawings of Willis (1676) and Huntington, saw the resemblance between these drawings (See Figs. 31, 30) and their own dissections on some animals and stated that "separate bronchi springing from the lobar bronchus with their attached secondary lobules constitute potential broncho-pulmonary segments", and that, "every orifice seen in a lobar bronchus supplies a segment or at times as in the calf, pig, and opossum a segmentellette (accessory to a segment) in a lobe." They have defined the broncho-pulmonary segment in their 1949 article as "a branch of the stem of a lobe of a lung which has on it secondary branches with masses of lung tissues called secondary lobules."

Lastly it is interesting to note the current text book definitions.

Grant's "Method of Anatomy" (1948) defines the broncho-pulmonary segment thus: "Each tertiary or segmental bronchus together with the portion of the lobe it supplies is called a broncho-pulmonary segment."

The latest (9th) edition of Cunningham's "Text Book of Anatomy" (1951) refers to the broncho-pulmonary segment, in the section on Respiratory System (by J.C.B. Grant), in the following words: "Each lobar bronchus divides into two or more tertiary or segmental bronchi for the supply of subdivisions or segments of the lobes of the lungs."

It will have been seen that each of the versions given above is a contribution representing viewpoints from different angles.

The apparent stress on the constancy of position of the segment and its bronchus contained in the original definition of Kramer and Glass has not been reiterated by any of the subsequent authors.

Adams and Davenport have introduced the idea of the avascular diverging planes and associated them with the existence of "complete or partial fissures". They have in addition described the form of the segment.

Jackson and Huber have made the conception of broncho-pulmonary segment less "rigid" and have brought in the idea of clinical importance.

Foster-Carter and Hoyle have called the segmental bronchus a "principal" branch of the lobar bronchus; these branches are "relatively constant", and "there can be variety in the shape and size of the segments". This definition reflects the flexibility of the notion.

Appleton's account is the most comprehensive. In addition to containing some of his own contributory ideas, his description embodies others from previous definitions. He has pointed out the arbitrary nature of the segments and that they can be dissected from their neighbours. What Adams and Davenport called the "avascular diverging planes" have been more correctly termed as the "intersegmental planes" (of connective tissue) as they contain tributaries of pulmonary veins. That obviously accounts for Appleton having omitted the adjective "avascular" used by Adams and Davenport.

Boyden's definition clearly implies a new fact that the

intersegmental planes may be crossed by arteries from one adjacent segment to the other.

Hardie-Neil and Gilmour have presented a different concept as they viewed the broncho-pulmonary segment from the comparative and developmental aspects.

The use of the term "tertiary" in the text books in respect of the segmental bronchus will be criticised presently.

It will be noticed that a number of facts and opinions have been recorded but there is no clear-cut statement of any criteria which one might make the basis for establishing the broncho-pulmonary segment in another mammal.

Some of the important facts about the broncho-pulmonary segment of the human lung that have been encountered above may now be examined, one by one, with a view to consider their applicability to dog's lung.

- (1) The broncho-pulmonary segment is a "separate respiratory district" -(Ewart).

In the lung of the dog, as in the human lung, each bronchus, irrespective of the generation to which it belongs, supplies a territory of its own, which would be a "separate respiratory district". This factor, therefore, cannot be considered as a criterion.

- (2) The broncho-pulmonary segment is a "subdivision of a pulmonary lobe" - (Kramer and Glass; Adams and Davenport).

On this point there is a general agreement. One common feature between dog's and human lungs is the existence of lobes whose homology is easy to determine. This permits the lobar basis for consideration of broncho-pulmonary segments in the dog

and has been made the first criterion. (See criterion 1, page 105) The presence of two additional lobes does not materially interfere with the acceptance of this principle. Difficulties would arise in the case of non-lobate lungs such as those of the horse (Sisson and Grossman, 1943), camel, elephant, orang-utan and hippopotamus (Huizinga and Pothoven, 1943) or in the lungs of mammals in which the lobar pattern is very much different, as in *Hystrix Cristata* which has numerous lobes (Narath, 1901).

- (3) The segmental bronchus has an orifice which is "easily visible to the bronchoscopist" - (Kramer and Glass)

This may hold true for the human segmental bronchi, but in view of the different anatomical conditions in the lungs of dog, making this a criterion would exclude a large number of bronchi which supply relatively large areas of the lung and which deserve to be considered as segmental bronchi no less than those which would be visible through the bronchoscope.

- (4) The broncho-pulmonary segment is "served by a principal branch of a lobar bronchus" - (Foster-Carter and Hoyle)

The term "principal", being subjective, is difficult to define.

There are two main series of bronchi in each lobe which, as previously mentioned, are in a roughly descending order of size. It is difficult to determine in each series the number of what may be called "principal" branches. However, it is possible to state that the proximal branches of the two main series are usually the largest of all the branches and may therefore be considered "principal" branches in each lobe. But exceptions do occur and some proximal branches may even be rudimentary.

The "principal" branches in the human lung, according to Foster-Carter and Hoyle, are "relatively constant". Kramer and

Glass state that the broncho-pulmonary segment is supplied by a "constantly placed" bronchus. Thus those proximal branches which are either "relatively constant" or "constantly placed" will be considered segmental in the dog. (See criteria 2 and 3, page 106)

- (5) The broncho-pulmonary segment "occupies a definite constant position in the pulmonary architecture" - (Kramer and Glass)

It has been proved by Brock, and Boyden and coworkers that the broncho-pulmonary segments are liable to variations in size. The same holds true for the dog. An absolute constant position, therefore, cannot be made a criterion.

- (6) The broncho-pulmonary segments are separated by "intersegmental planes" of connective tissue - (Appleton)

During the course of dissections no visible planes of connective tissue were recognised in the dog's lung. However, it was possible, in preserved specimens, to dissect the segments apart and along the planes of cleavage veins were encountered.

- (7) The "avascular diverging planes may or may not be indicated by complete or partial fissures." - (Adams and Davenport)

During the course of study a record was kept of all rudimentary fissures and their positions in relation to segments determined. The details of this study and the conclusions arrived at are deferred till the broncho-pulmonary segments have been studied. (Vide page 30).

- (8) "Every orifice seen in a lobar bronchus supplies a segment or a segmentallette." - (Hardie-Neil and Gilmour)

This was Hardie-Neil and Gilmour's conclusion after a brief comparative study. The general arrangement of the bronchi in the lobes of the dog's lung is in complete accord with this opinion. Every bronchus, therefore, which springs from the lobar bronchus is, strictly speaking, a segmental bronchus and

should be accepted as such. But in that case each lobe would present a very complicated picture and no two lungs or lobes would possess identical patterns. Only those bronchi which will be found to fulfil certain definite criteria, to be defined later, will be accepted as "proper" segmental bronchi.

- (9) Shape of the broncho-pulmonary segments - "Its apex lies in the hilus and its base fills an area of the lung periphery"
- (Adams and Davenport)

Dogs' lungs are flat as compared to the laterally expanded human lungs. The segments of the former, therefore, as will be seen later, possess different shapes so that this description was not found generally applicable to the broncho-pulmonary segments of the dog.

- (10) The broncho-pulmonary segment is supplied by a "tertiary" bronchus.

Objection to the use of terms, primary, secondary and tertiary was raised by Neil, Gilmour and Gwynne (1939) in view of the different interpretations given by different workers. This led them to suggest the term "segmental bronchus" to avoid this confusion. Later this objection was raised by Foster-Carter (1942) because these terms are "misleading". Smyth (1949) has also pointed out the confusion in naming the bronchial divisions when he states that the left posterior segmental bronchus in the upper lobe is "a fourth generation bronchial branch", whereas, "the superior segmental bronchus" of the lower lobe is a "second generation branch".

The concept of tertiary bronchus is obviously based on the assumption that the two primary bronchi, the result of bifurcation of trachea, terminate by giving off three "secondary" (lobar) bronchi on the right and two on the left. In turn the "lobar"

bronchi divide into tertiary bronchi.

The present generally accepted concept, however, despite the controversy with regard to the existence of the "stem-bronchus" in the human lungs is that the lower lobes are supplied by the continuation of the primary bronchi after they have given off the bronchi to other lobes.

The status each bronchus in the human lungs would assume in terms of primary, secondary or tertiary branches according to whether the former or the latter concept be accepted as true is indicated in Table 5 in columns 1 and 2 respectively. The discrepancies that arise are obvious.

Same remarks are applicable to the dog's lungs, as the arrangement of the main lobar bronchi is similar to that in the human lung. The existence of the independent intermediate lobe, however, adds to the confusion because its bronchus which is a lobar bronchus would be secondary whether considered under column 1 or 2 in the Table, whereas the corresponding medial basal segmental bronchus of the right human lobe is tertiary under column 1 and secondary under column 2.

Thus the text-book definition which appears to be the most definite does not prove to be so on analysis and is not applicable to the dog.

Criteria for Broncho-pulmonary Segments in the Dog

From the foregoing considerations the following three criteria are suggested and used in this study:-

1. That a broncho-pulmonary segment should be a part of a lobe.

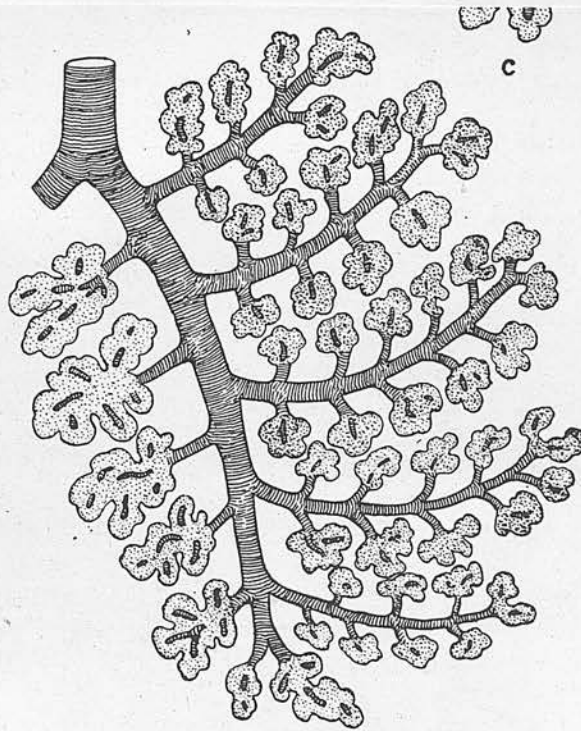


Fig. 30 . Structure of the Mammalian Lung.
(After Huntington, 1920.His Fig.7)

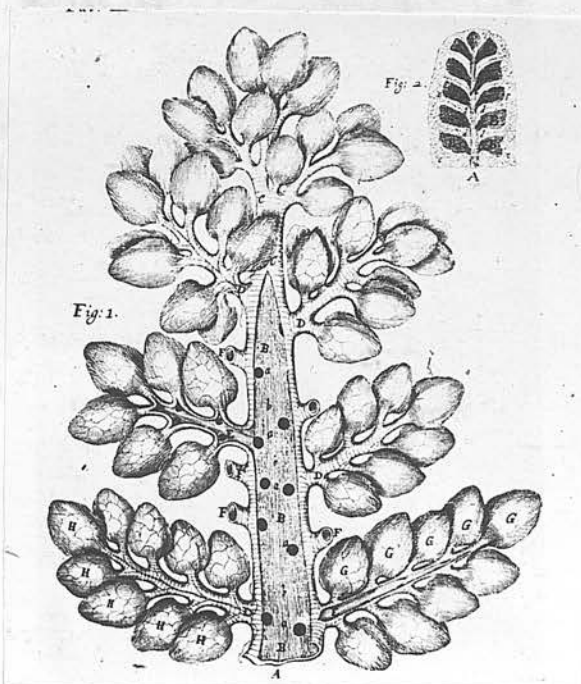


Fig. 31 . Structure of the lobe of a lung
according to Willis (1622-75).
(After Miller, 1950)

Table 5. (Explanation in Text)

	Name of Bronchus	Column 1	Column 2
<u>MAIN BRONCHUS</u>	Right Left	Primary "	Primary "
<u>LOBAR BRONCHUS</u>	Right Upper Lobe Right Middle Lobe Right Lower Lobe Left Upper Lobe Superior Division Lingular (Lower) Division Left Lower Lobe	Secondary " " " Tertiary Tertiary Secondary	Secondary " Primary Secondary Tertiary Tertiary Primary
<u>SEGMENTAL BRONCHUS</u>			
RIGHT UPPER LOBE	{ Apical Posterior Anterior	Tertiary " "	Tertiary " "
RIGHT MIDDLE LOBE	{ Lateral Medial	" "	" "
RIGHT LOWER LOBE	{ Apical Medial Basal Anterior Basal Lateral Basal Posterior Basal	" " " " "	Secondary " " " Primary
LEFT UPPER LOBE	{ Apico-Posterior Anterior Superior (Lingular) Inferior (Lingular)	Quaternary " " "	Quaternary " " "
LEFT LOWER LOBE	{ Apical Anterior Basal Lateral Basal Posterior Basal	Tertiary " " "	Secondary " " Primary

2. That the bronchus of a broncho-pulmonary segment should have a "constant" or "relatively constant" position on the stem bronchus of the lobe.

3. That it should either "constantly" or with a "relative constancy" be served by a principal bronchus.

This makes it necessary to explain the terms "constant" and "relatively constant", as used in this study. In the absence of any standard value attached to a "relatively constant" finding, it is proposed to consider a value of 50% or over as representing a relative constancy, and the value of 100% has been taken to represent a constant finding.

At the end it may be pointed out that one of the guiding principles in the final establishment of the universally accepted broncho-pulmonary segments of the human lung has been their clinical importance. Such a guidance is lacking in the dog.

It is realised that the criteria stated above are suggested for their applicability to the lungs of dog only, which possess lobes and that they would need a reconsideration afresh when dealing with lungs in which the different pattern of lobes may not permit their application.

THE PROCEDURE ADOPTED FOR ESTABLISHING THE
BRONCHO-PULMONARY SEGMENTS IN THE DOG

It has been stated previously that every branch of the lobar stem bronchus, as emphasised by Hardie-Neil and Gilmour (see page 103), deserves the status of a bronchus supplying a segment or a segmentellette, but in that case each lobe would present a very complicated segmental pattern.

Keeping in view the criteria which have already been suggested, the following method has been adopted for establishing the broncho-pulmonary segments:-

The search has been made on lobar basis.

The first step has been to find out in each lobe the bronchi which exhibit a constant or a relatively constant position on the lobar stem bronchus.

The second step consists of determining which bronchi out of these are, constantly or with a relative constancy, principal bronchi, i.e., bronchi which serve segments and not segmentellettes.

Those bronchi which fulfil the above conditions have been accepted to represent the segmental bronchi. The empirical pattern of segments which thus emerged has been considered as the basis for recording variations.

Accordingly the procedure has been as follows:-

In each lobe the numerical position of every bronchus, arising from the lobar stem bronchus, as far as traceable, has already been noted and recorded in Charts I, II, III, IV, V, VI, VII and VIII.

From these charts the numerical position of each of the branches of the two main series was analysed. The most frequent numerical position exhibited by each branch in the total number of lobes examined was then noted.* The number of lobes which

* See footnote on Table 6 .

showed this position was then expressed as a percentage of the total number of lobes.

Here it is necessary to explain a difficulty encountered. It has been seen that some of the branches originate from the lobar stem bronchus opposite each other. These branches have been indicated in the Charts referred to above, as already explained, by placing oblique lines between them. It is difficult in such cases to attribute the numerical position to each of the opposing branches. Two examples will explain how this difficulty has been overcome:-

(1) In Chart *I* of the right apical lobe, bronchus D_1 holds the 2nd and bronchus V_1 the 3rd position in 33 out of 37 lobes. In the remaining 4 lobes (specimens M_3 , M_4 , M_6 and M_7) they originate opposite each other.

Either of the two bronchi could be interpreted as holding a 2nd or 3rd position. It became problematic to decide for practical purposes which of these two positions be attributed to each of the two bronchi in these 4 lobes. As there is an equal chance for either branch to hold the 2nd or the 3rd position, the position of bronchus D_1 has been considered as 2nd in two (50%) and that of bronchus V_1 as 3rd. in the remaining 2 lobes. Consequently the most frequent position of bronchus D_1 has been shown to be 2nd in 35 and of bronchus V_1 3rd in 35 lobes instead of 33.

(2) In the same chart the most frequent position held by bronchus D_3 (including d_3) is 7th in 14 lobes. In addition it holds either a 6th or 7th position in 2 specimens (M_4 and E_{34}) and in another 3 specimens (M_{14} , E_{29} and E_{30}) it holds a 7th or 8th position. Thus in 5 additional lobes it holds 7th as an alternative position. Fifty % of these 5 lobes, i.e. 2.5 lobes, have been presumed to exhibit a 7th position. The total number of lobes in which D_3 holds a 7th position is therefore 14 plus 2.5 i.e. 16.5 lobes (44.60%).

Multiple other similar situations were tackled in the same way.

Findings with regard to the relatively constant or constant bronchi, i.e. those bronchi, in each lobe, which exhibit a constancy of numerical position of 50% or over, are given in columns 3 and 4 of Table 6. Those exhibiting a frequency of under 50% have been omitted in this Table.

It will be noticed that the maximum degree of constancy of

Table 6

FREQUENCY OF THE NUMERICAL POSITIONS OF THE "CONSTANT" AND THE "RELATIVELY CONSTANT" BRONCHI,
AND OF THE SIZES OF AREAS SUPPLIED, IN TERMS OF "NORMAL", "OVERDEVELOPED",
AND "UNDERDEVELOPED" SEGMENTS

(1) Lobe and the No. of specimens examined	(2) Bronchus	(3) Most frequent numerical posi- tion exhibited by the bronchus	(4) No. of Lobes exhibiting this position and percentage	(5) No. of Lobes in which the bronchus supplies normal-sized and overdeveloped segments, and percentages			(6) No. of Lobes in which the bronchus supplies an under- developed segment (a segmentallete) and percentage.
				(A)	(B) No. of normal- sized segments and per- centage	(C) No. of over- developed segments and percent- age	
Right Apical (37)	D1	2nd	35 (94.59%)	37 (100%)	36 (97.3%)	1 (2.70%)	0
	D2	4th	20.5 (55.4%)	23 (62.16%)	23 (62.16%)	0	14 (37.83%)
	P	1st	37 (100%)	37 (100%)	37 (100%)	0	0
	V1	3rd	35 (94.59%)	37 (100%)	37 (100%)	0	0
	V2	5th	20 (54.05%)	34 (91.89%)	33 (89.18%)	1 (2.7%)	3 (8.1%)
Right Cardiac (28) *	P1	1st	28 (100%)	28 (100%)	28 (100%)	0	0
	P2	3rd	25.5 (91.07%)	28 (100%)	27 (96.42%)	1 (3.57%)	0
	A1	2nd	26 (92.85%)	28 (100%)	28 (100%)	0	0
	A2	4th	24.5 (87.5%)	28 (100%)	24 (85.71%)	4 (14.3%)	0
Right Dia- phragmatic (31)	D1	1st	30.5 (98.38%)	31 (100%)	31 (100%)	0	0
	D2	3rd	28.5 (91.93%)	31 (100%)	31 (100%)	0	0
	V1	2nd	28.5 (91.93%)	31 (100%)	31 (100%)	0	0
	V2	4th	17.8 (57.42%)	30 (96.77%)	30 (96.77%)	0	1 (3.22%)
Inter- mediate (32)	D1	1st	20.5 (64.06%)	31 (96.87%)	0	31 (96.87%)	1 (3.12%)
	V1	4th	17.5 (54.68%)	25 (78.12%)	15 (46.87%)	10 (31.25%)	7 (21.87%)
Left Apical (33)	D1	1st	33 (100%)	33 (100%)	32 (96.96%)	1 (3.03%)	0
	D2	3rd	24 (72.72%)	29 (87.87%)	23 (69.69%)	6 (18.18%)	4 (12.12%)
	D3	5th	20 (60.6%)	23 (69.69%)	19 (57.57%)	4 (12.12%)	10 (30.30%)
	V1	2nd	28 (84.84%)	33 (100%)	27 (81.81%)	6 (18.18%)	0
	V2	4th	18 (54.54%)	29 (87.87%)	27 (81.81%)	2 (6.06%)	4 (12.12%)
Left Cardiac (33)	P1	1st	33 (100%)	33 (100%)	33 (100%)	0	0
	P2	3rd	28 (84.84%)	33 (100%)	33 (100%)	0	0
	P3	5th	17.5 (53.03%)	32 (96.96%)	31 (93.93%)	1 (3.03%)	1 (3.03%)
	A1	2nd	32.5 (98.48%)	33 (100%)	20 (60.60%)	13 (39.39%)	0
	A2	4th	25 (75.75%)	16 (48.48%)	4 (12.12%)	12 (36.36%)	17 (51.51%)
Left Dia- phragmatic (33)	D1	1st	33 (100%)	33 (100%)	33 (100%)	0	0
	D2	3rd	32 (96.96%)	33 (100%)	33 (100%)	0	0
	D3	6th	17 (51.51%)	33 (100%)	33 (100%)	0	0
	V1	2nd	33 (100%)	33 (100%)	33 (100%)	0	0
	V2	4th	29.5 (89.39%)	33 (100%)	33 (100%)	0	0

* The total number of specimens included in Chart II of right cardiac lobes is 33, whereas the findings in this

the position on the lobar stem bronchus is exhibited by the proximal branches. Each successive branch shows a diminishing degree of it.

These branches, shown in Table 6, were further analysed to find out the frequency with which these bronchi supplied segmentellettes. It will be noticed from column 5(A) of the Table that all bronchi supply segments in more than 50% of the lobes, with the exception of bronchus A₂ of left cardiac lobe, which in 51.51% of the specimens ^(Column 6) supplies segmentellettes and cannot therefore be accepted as a principal bronchus. Bronchus A₂, therefore, has been rejected as a segmental bronchus. The rest of the bronchi in the Table, all of which now fulfil the criteria for broncho-pulmonary segments, are accepted as segmental bronchi and provide the empirical basic segmental pattern in each lobe.

All the remaining bronchi, in each lobe, which have been rejected as "segmental" bronchi, are, with their areas of supply grouped together as one single "segment", termed the "Terminal" segment (symbol T is suggested and used as an abbreviation for it). The T-segment would thus be a composite segment consisting of a varying number of true segments.

The basic segmental patterns that emerge for all lobes are expressed below. (The segments of the two opposite series are shown above and below the line respectively and the T-segment is placed opposite the line as it comprises segments from both series).

	<u>Right Lung</u>	<u>Left Lung</u>
Apical Lobe	$\frac{D_1, D_2}{P, V_1, V_2}, T$	$\frac{D_1, D_2, D_3}{V_1, V_2}, T$

	Right Lung	Left Lung
Cardiac Lobe	$\frac{P_1, P_2}{A_1, A_2}, T$	$\frac{P_1, P_2, P_3}{A_1}, T$
Diaphragmatic Lobe	$\frac{D_1, D_2}{V_1, V_2}, T$	$\frac{D_1, D_2, D_3}{V_1, V_2}, T$
Intermediate Lobe	$\frac{D_1}{V_1}, T$	

Thus the right lung is divided into 19 and the left into 17 broncho-pulmonary segments.

It must be stressed that the pattern of segments arrived at is only an empirical pattern, a useful basis for recording variations. No lung, however, may exhibit this "typical" picture.

RIGHT CARDIAC LOBE (33 specimens)*	$\frac{P_1, P_2}{A_1, A_2}, T$	27	81.81
	$\frac{P_1, P_2}{A_1, A_2}, T$	4	12.12
	$\frac{P_1, P_2}{A_1, A_2}, T$	1	3.03
	$\frac{P_1, P_2}{A_1}, T$	1	3.03
RIGHT DIAPHRAGMATIC LOBE (31 specimens)	$\frac{D_1, D_2}{V_1, V_2}, T$	30	96.77
	$\frac{D_1, D_2}{V_1, V_2}, T$	1	3.23

* These 33 specimens include 5 lobes, in which bronchi V_1 and V_2 are joined by a common stem. (See footnote on Table 4). The empirical pattern, however, in these 5 lobes, remains unaffected.

VARIATIONS IN THE PATTERNS OF BRONCHO-
PULMONARY SEGMENTS ACCORDING TO THEIR SIZE

Representing the variations, by employing the signs and symbols already explained, the different patterns observed in each lobe are tabulated below:-

	<u>Pattern</u>	<u>No. of Lobes</u>	<u>Percentage</u>
RIGHT APICAL LOBE (37 specimens)	$\frac{D_1, D_2}{P, V_1, V_2}, T$	21	56.75
	$\frac{D_1, d_2}{P, V_1, V_2}, T$	12	32.43
LEFT APICAL LOBE (33 specimens)	$\frac{D_1+, d_2}{P, V_1, v_2}, T$	1	2.7
	$\frac{D_1, D_2}{P, V_1, v_2}, T$	2	5.4
	$\frac{D_1, d_2}{P, V_1, V_2+}, T$	1	2.7
RIGHT CARDIAC LOBE (33 specimens)*	$\frac{P_1, P_2}{A_1, A_2}, T$	27	81.81
	$\frac{P_1, P_2}{A_1, A_2+}, T$	4	12.12
	$\frac{P_1, P_2+}{A_1, A_2}, T$	1	3.03
	$\frac{P_1, P_2}{A_1+, a_2}, T$	1	3.03
RIGHT DIAPHRAGMATIC LOBE (31 specimens)	$\frac{D_1, D_2}{V_1, V_2}, T$	30	96.77
	$\frac{D_1, D_2}{V_1, v_2}, T$	1	3.22

* These 33 specimens include 5 lobes, in which bronchi P_1 and A_1 arise by a common stem. (See footnote on Table 6). The segmental pattern, however, in these 5 lobes, remains unaffected.

	<u>Pattern</u>	<u>No. of Lobes</u>	<u>Percentage</u>
INTERMEDIATE LOBE (32 specimens)	$\frac{D_1^+}{V_1^+}, T$	10	31.25
	$\frac{D_1^+}{V_1}, T$	7	21.87
	$\frac{D_1^+}{V_1}, T$	14	43.74
LEFT CARDIAC LOBE (33 specimens)	$\frac{d_1}{V_1}, T$	1	3.12
LEFT APICAL LOBE (33 specimens)	$\frac{D_1, D_2, D_3}{V_1, V_2}, T$	12	36.36
	$\frac{D_1, D_2, d_3}{V_1, V_2}, T$	3	9.09
	$\frac{D_1, d_2, D_3}{V_1, V_2}, T$	1	3.03
LEFT DIAPHRAGMATIC LOBE (33 specimens)	$\frac{D_1, d_2, D_3}{V_1, V_2}, T$	1	3.03
	$\frac{D_1, D_2^+, d_3}{V_1, V_2}, T$	3	9.09
	$\frac{D_1, D_2^+, D_3}{V_1, V_2}, T$	1	3.03
	$\frac{D_1, D_2, d_3}{V_1^+, V_2}, T$	1	3.03
	$\frac{D_1, D_2, D_3^+}{V_1, V_2}, T$	2	6.06
	$\frac{D_1, d_2, D_3^+}{V_1, V_2}, T$	2	6.06

	<u>Pattern</u>	<u>No. of Lobes</u>	<u>Percentage</u>
LEFT APICAL LOBE continued (33 specimens)	$\frac{D_1, D_2, D_3}{V_1^+, V_2}, T$	2	6.06
	$\frac{D_1, D_2^+, d_3}{V_1, V_2^+}, T$	2	6.06
	$\frac{D_1, D_2, D_3}{V_1^+, V_2}, T$	2	6.06
LEFT CARDIAC LOBE (33 specimens)	$\frac{P_1, P_2, P_3}{A_1}$	19	57.57
	$\frac{P_1, P_2, P_3^+}{A_1^+}, T$	1	3.03
	$\frac{P_1, P_2, P_3}{A_1^+}, T$	12	36.36
	$\frac{P_1, P_2, P_3}{A_1}, T$	1	3.03
LEFT DIAPHRAGMATIC LOBE (33 specimens)	$\frac{D_1, D_2, D_3}{V_1, V_2}, T$	33	100

It may be noticed that in each lobe the prevailing pattern corresponds to the "empirical basic" patterns worked out before (vide page //0).

It will also be noticed that the least number of variations exist in the two diaphragmatic lobes, the left lobe showing none; the left apical lobe exhibits the maximum number of variations.

It may be emphasized that the above classification of the variations is based only on the size of segments. A consideration of the sequence of origins of the segmental bronchi would further complicate this classification.

1) segment MORPHOLOGY OF BRONCHO-PULMONARY SEGMENTS
2) AND SEGMENTAL BRONCHI

3) General Remarks

4) The basic pattern of the broncho-pulmonary segments having been worked out, it is now intended to deal with the segments and their bronchi in a little more detail, and also to record the variations in the patterns observed.

5) Information with regard to the position and size of each segment was obtained from casts as well as dissected specimens. It may be pointed out here that a well injected cast provides almost as much information about these points as does a dissected specimen. The information gathered from casts and dissections was then confirmed by demonstrating the segments by injecting coloured gelatin in two pairs of lungs.

6) The shape and relative size of each segment, and therefore its surface projection, are liable to minor and sometimes considerable variations but these have not been dealt with. A general idea of the relative sizes of segments may be obtained by referring to Figs. 32A, 32B, 32C, 33A and 33B.

7) It may be pointed out here that although the segments possess a more or less constant position in relation to each other the numerical positions of the segmental bronchi on the lobar stem bronchi, as has been seen already, is variable.

8) It will be noticed, from Figures above mentioned, that generally each segment overlaps the succeeding segment in such a way that the T segment is wedged in between segments of the opposing series. Thus it will be seen that the T segments are fitted into the angles between:-
the other segments.

- 1) segments D₂ and V₂ in the right apical lobe
- 2) " P₂ " A₂ " " right cardiac lobe
- 3) " D₂ " V₂ " " right diaphragmatic lobe
- 4) " D₃ " V₂ " " left apical lobe
(In the injected specimen illustrated, it is between segment D₂ and V₂, as D₃ is a segmentellette (d₃))
- 5) segments A₁ and P₃ (& P₂) in the left cardiac lobe
- 6) " D₃ " V₂ " " left diaphragmatic lobe
- 7) " D₁ " V₁ " " intermediate lobe

The true segments (i.e., those other than the composite T segments) are arranged in opposite halves of each lobe. At the intersegmental planes the segments overlap each other to variable extents.

The shape of a segment depends upon its location. The ventral segments of the two apical, the two diaphragmatic and all the segments of the two cardiac lobes, are wedge shaped on account of the acute angles made by surfaces which meet at the sharp borders along which the segments are arranged.

The dorsal segments of the diaphragmatic lobes and of the apical lobes are arranged along the dorsal borders of the lungs. These borders are thick and rounded in the region of the diaphragmatic lobes; the dorsal segments of these lobes, therefore, present on section the appearance of a sector of a disc with a circular periphery. In the region of the apical lobes, the dorsal borders being thinner, this appearance is lost and the segments are flattened from side to side.

The shape and extent of the T segment in each lobe depends upon the size of the lobe and the extent of the area occupied by the other segments.

The shapes of the segments of the intermediate lobe and of those that have some peculiarities are described later.

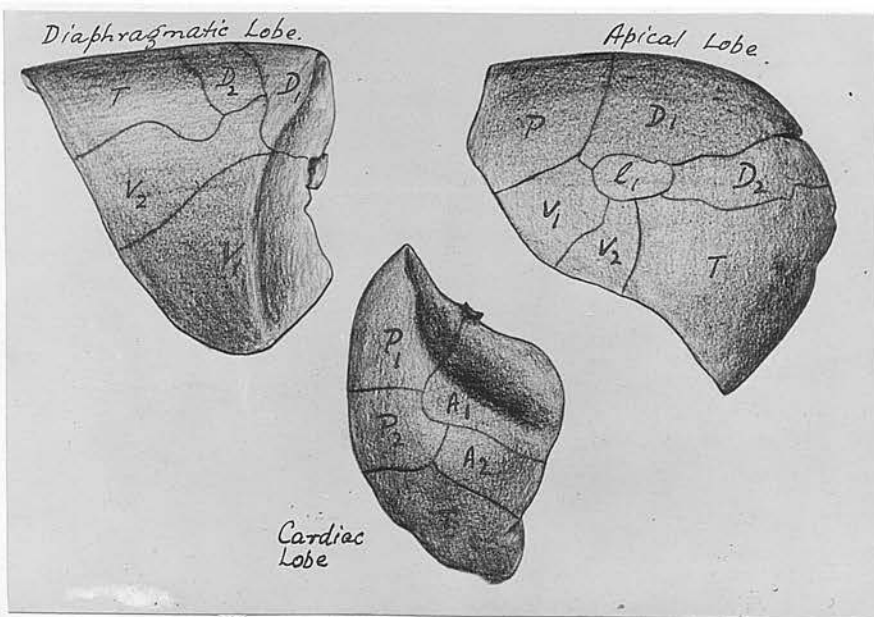
Each segment presents itself on definite surfaces of the lung. The extent of the surface projection of each segment and the extent to which it contributes towards the formation of the border of the lobe is directly related to its size.

All segmentellettes fail to reach the borders so that they are embedded between the adjoining segments (Figs. 33A, 33B. -d₃)

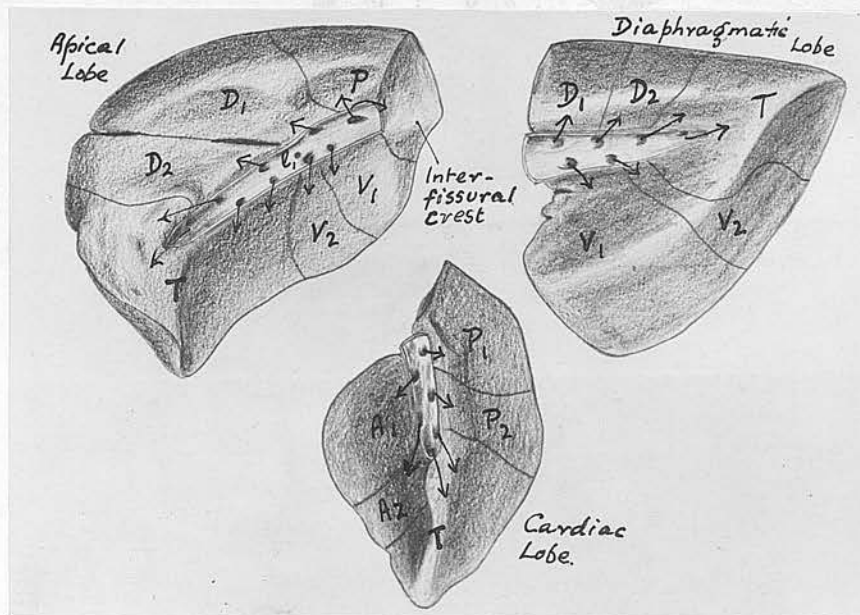
The frequencies with which the various segments were found to be normally developed, overdeveloped, or underdeveloped may be studied by reference to columns 5B, 5C and 6 respectively in Table 6 . It will be noticed that with the exception of segments D₂ and V₂ of right apical, V₂ of right diaphragmatic, D₁ and V₁ of intermediate, D₂, D₃ and V₂ of left apical and P₃ of left cardiac lobe, in which some of the segments are segmentellettes, all other segments are either normally developed (in the majority of specimens) or are overdeveloped.

In the succeeding account some of the segments in a series have been described collectively to avoid repetition of common features.

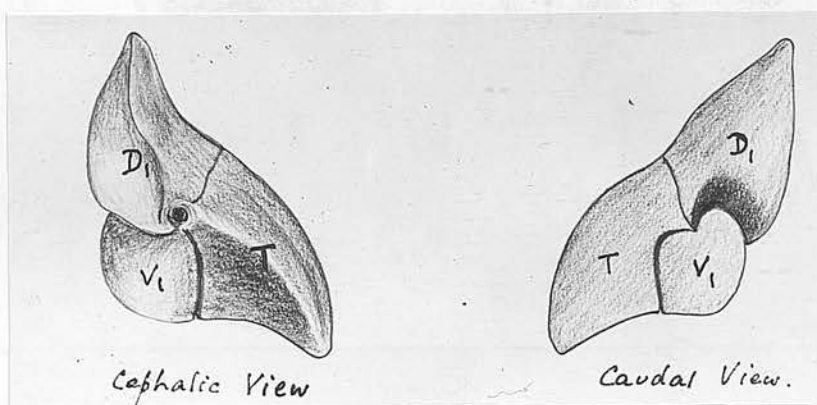
Figs. 32, A, B & C. Drawings of a right lung of dog in which the individual segments were injected with colored gelatine. Lobes shown apart.



A. Lateral View
(1 = area
supplied by
accessory
bronchus 1

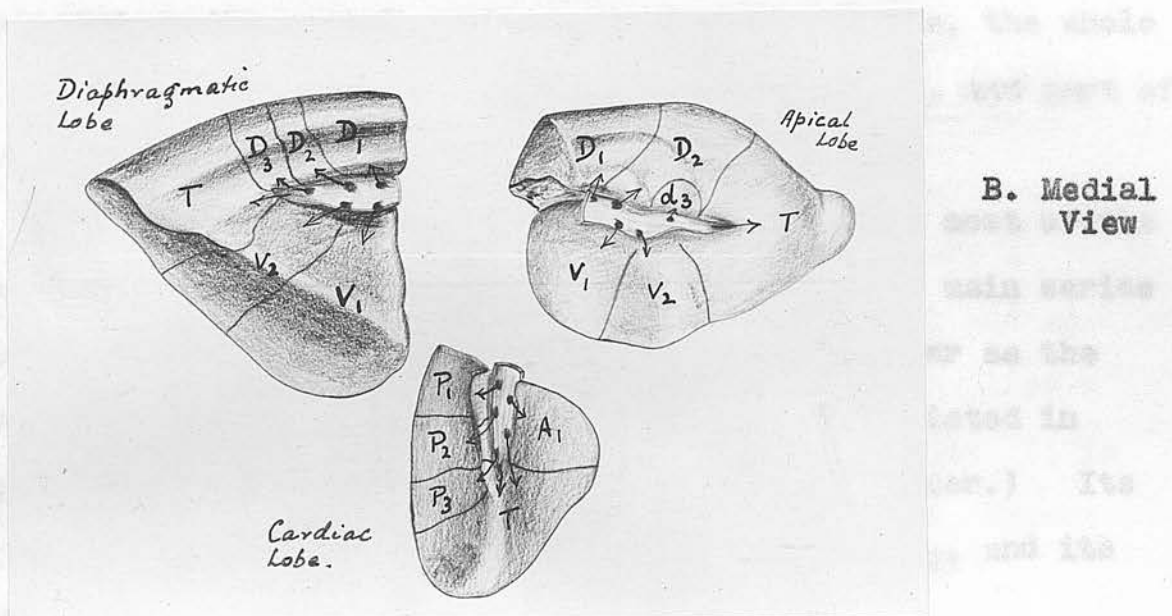
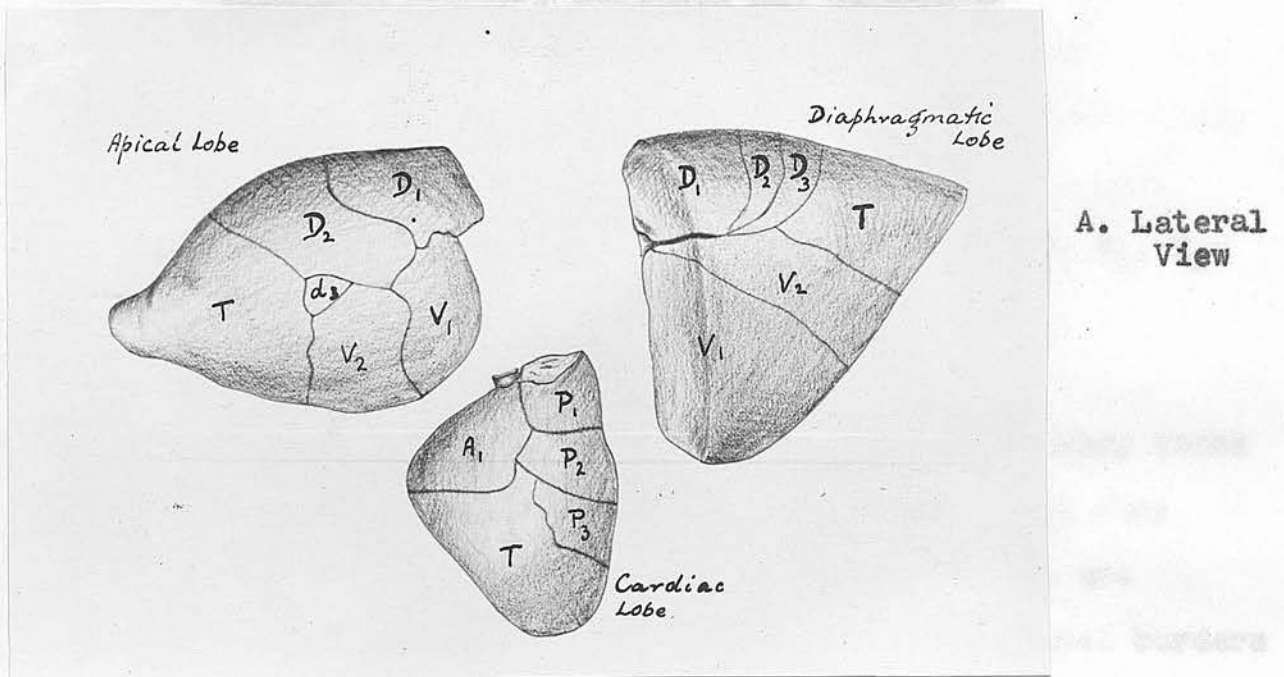


B. Medial View



C. Intermediate
Lobe

Figs. 32, A, B & C. Drawings of a right lung of dog in which the individual segments were injected with coloured gelatine. Lobes shown apart.



Figs. 33 , A & B. Drawings of a left lung of dog in which the individual segments were injected with coloured gelatine. Lobes shown apart.

Broncho-Pulmonary Segments and Segmental
Bronchi of Individual Lobes

The Right Apical Lobe
(Figs. 19, 32A, 32B)

The right apical lobe comprises six segments, P, V₁, V₂, D₁, D₂ and T.

Segment P

Bronchus P, supplying this segment, originates very close to or sometimes even a little outside the hilum. It runs laterally and caudally to divide into branches which are directed towards the dorsal, the ventral and the caudal borders of the lobe. They supply a quadrilateral area which is situated caudal and dorsal to the hilum of the lobe. It is projected on the costal surface, the medial surface, the whole of the fissural surface for the diaphragmatic lobe, and part of the fissural surface for the cardiac lobe.

This segment, as judged from its position, in most of the specimens, appears to belong to neither of the two main series because it forms almost as much of the dorsal border as the ventral border of the lobe. (In the specimen depicted in Fig. 32 it forms a greater part of the dorsal border.) Its dorsal part is in alignment with segments D₁ and D₂, and its ventral part with segments V₁ and V₂.

It has been considered a member of the ventral (V) series for two reasons:-

(1) At the origin its bronchus falls in series with the "spirally" arranged bronchi of the V series.

(2) It will be seen from Chart I of right apical lobe that only a small part of the dorsal border (Fig. 32A)

the first few (about four) branches of the two series in each lobe, show a tendency to alternate, which tendency diminishes as the branches are followed distally. Bronchus P definitely falls in with the V-branches among these early alternating dorsal and ventral branches.

But in order to emphasise the peculiar position of this bronchus letter V has not been employed to denote it. It will be seen later that this segment corresponds to the "Posterior" segment of the right apical lobe of the human lung. Preference has, therefore, been given to letter P to indicate it. The absence of a numeral with it distinguishes it from the P branches of the cardiac lobe.

The interfissural crest is situated on this segment (Fig. 32B).

Segment D₁

Segmental bronchus D₁ is a constantly large bronchus. It is directed almost cephalically with a dorsal inclination tending to reach the apex of the lung. It gives off a prominent series of branches from its dorsal aspect and smaller irregular branches from its ventral aspect. It supplies a large triangular area next in size to the T segment. It is projected on costal and mediastinal aspects. This segment forms a large part of the dorsal border of the lobe.

Segment D₂

As compared to segment D₁ it is a smaller segment. In a fully developed segment its bronchus runs parallel to bronchus D₁ (Figs. 19, 25A) and gives off small branches from its sides. It is projected on costal and mediastinal aspects. It forms only a small part of the dorsal border (Fig. 32A).

Segment V₁

This segment intervenes between segments P and V₂. Its bronchus runs ventro-laterally towards the ventral border of the lobe with a caudal or a cephalic inclination. It is projected on the costal surface and the fissural surface for the cardiac lobe.

Segment V₂

Segment V₂ is usually smaller than segment V₁. Its bronchus runs ventro-laterally towards the ventral border of the lobe. The segment is projected on the costal surface, the fissural surface for the cardiac lobe and a part of the mediastinal surface in the region of the cardiac impression.

Segment T

The T segment comprises almost half of the lobe and is the largest of the six segments. It is projected on the costal surface, the mediastinal surface and the cardiac surface. It bears on it the terminal end of the lobe and in the majority of specimens the apex of the right lung. (Details of the bronchial supply of the apex are dealt with later.) On its medial aspect it bears the mediastinal crest of the lobe which is supplied by the "m" branches, arranged under the crest, sometimes in a row.

The Right Cardiac Lobe

(Figs. 19, 25A, 32A, 32B)

The right cardiac lobe consists of five segments, P_1 , P_2 , A_1 , A_2 and T.

Segment P_1

The segmental bronchus P_1 runs caudally, ventrally and laterally to supply an area which occupies the dorsal end of the lobe and is projected on the costal surface, the fissural surface for the diaphragmatic lobe and the fissural surface for the apical lobe. It bears on it the interfissural crest.

Segment P_2

Segment P_2 is smaller than the preceding segment. Its bronchus runs parallel to bronchus P_1 and supplies an area which is projected on the costal surface and the fissural surface for the diaphragmatic lobe.

Segment A_1

The bronchus supplying this segment runs in a cephalic, ventral and lateral direction. The segment presents itself on the cardiac surface, the fissural surface ^{for the apical lobe} and to a variable extent on the costal surface.

Segment A_2

The segmental bronchus A_2 runs parallel to bronchus A_1 and supplies an area smaller than segment A_1 . It is projected on the costal and the cardiac surfaces.

Segment T

The T segment comprises the distal half or more of the lobe. It presents itself on the costal surface, the cardiac

surface and the caudal surface. It bears the ventral half or more of the crest on the medial aspect of the lobe.

The Left Apical Lobe

(Figs. 20, 24B, 33A, 33B)

The left apical lobe consists of six segments: D₁, D₂, D₃, V₁, V₂ and T.

Segment D₁

The segmental bronchus D₁ runs dorsally and in a slightly cephalic direction. It gives off branches which supply a roughly quadrilateral area which is projected on the costal surface, the medial surface and the fissural surface for the diaphragmatic lobe, dorsal to the level of the hilum. The segment is fused with segment P₁ of the left cardiac lobe.

Segments D₂ and D₃

The bronchi of these two segments run dorsally with varying degrees of cephalic inclinations in different lobes. The segments are projected on the costal and the medial surfaces.

In Figs. 33A and 33B, segment D₃ can be seen to be embedded between segments D₂ and T, and is a segmentellette. It is also a segmentellette in Fig. 20. In Fig. 24B bronchus D₂ supplies a segmentellette.

Segments V₁ and V₂

Segmental bronchi V₁ and V₂ run ventrally with cephalic inclinations. Segment V₁ and a variable part of segment V₂ lie opposite the minor fissure. The surfaces on which they

are projected depend upon which of the two lobes, the apical or the cardiac, overlaps the other.

illustrated in Fig. 33

In specimen_A the apical lobe overlapped the cardiac lobe.

In such a case both segments appear on the costal surface and the fissural surface for the cardiac lobe which faces medially. When the cardiac lobe overlaps the apical lobe the fissural surface faces laterally. These segments then appear on this surface and on the mediastinal (cardiac) surface.

Segment T

This is the largest segment and possesses a mediastinal and a costal surface. It has the apex of the lung on it.

The Left Cardiac Lobe

(Figs. 20, 24B, 25B, 33A, 33B)

The left cardiac lobe has been divided into five segments:

P₁, P₂, P₃, A₁ and T.

Segments P₁, P₂ and P₃

Bronchi P₁, P₂, P₃ supplying these segments run laterally and caudally with ventral inclination up to the caudal border of the lobe.

All three segments present themselves on the costal surface and the fissural surface for the diaphragmatic lobe. Segment P₁ does not, as does segment P₁ of the right cardiac lobe, present any fissural surface at the minor fissure as this is fused to segment D₁ of the left apical lobe, except in those few cases in which the minor fissure is connected to the major fissure in the form of a deep groove.

Segment A₁

Segment A₁, supplied by bronchus A₁, was found to be very variable in size. (Compare Figs. 20, 24B and 25B: see Table 6 column 5).

The segment lies opposite the minor fissure either lateral or medial to the plane of segments V₁ and V₂ of the left apical lobe, depending upon which lobe overlaps the other. The surfaces on which it appears vary accordingly.

The segment forms the dorsal part of the thin cephalic border of the lobe, and in specimens in which it is overdeveloped, almost the whole of the cephalic border.

Bronchus A₃, in the specimen illustrated in Fig. 20, and bronchus A₂, in Fig. 24B, are markedly overdeveloped but they have been included in the T segment because of their inconstant positions on the lobar stem bronchi and variable sizes in other lobes.

Segment T

As in the right cardiac lobe it is the largest segment in the lobe. In the majority of specimens it extended more along the cephalic border of the lobe, but in those specimens in which segment A₁ is overdeveloped, its extension along this border is very much reduced. (Compare Figs. 20 and 24B). It is projected on the costal surface, cardiac surface and fissural surface for the diaphragmatic lobe.

The Right Diaphragmatic Lobe

(Figs. 19, 26B, 32A, 32B)

The right diaphragmatic lobe comprises five segments:

D₁, D₂, V₁, V₂ and T. The dorsal segments are much smaller than the ventral segments.

Segments D₁ and D₂

Segmental bronchi D₁ and D₂ are directed dorso-laterally and caudally. Their branches fan out to the periphery of the thick rounded dorsal border of the lobe to supply areas which are projected on the medial, dorsal and lateral (costal) aspects of the border. Segment D₁, which is the bigger of the two, has in addition a fissural surface dorsal to the level of the hilum of the lobe which opposes the apical lobe.

Segment V₁

Bronchus V₁ is directed ventro-laterally and caudally. It divides into 2 to 3 large branches which supply an area which is projected on a large portion of the costal surface, the medial surface, the diaphragmatic surface and the fissural surface for the cardiac lobe.

Segment V₂

Segment V₂ is smaller than segment V₁. Its bronchus is directed more caudally than bronchus V₁. The segment is projected on the costal, the medial and the diaphragmatic surface.

Segment T

This segment is roughly quadrilateral in shape. It is projected on the costal, the medial and the diaphragmatic surface and forms the caudal half of the dorsal border which in this region is a convex surface.

The Left Diaphragmatic Lobe

(Figs. 20, 24B, 25B, 33A, 33B)

The left diaphragmatic lobe consists of six segments:

D₁, D₂, D₃, V₁, V₂, and T. Except for the additional segment D₃, situated between segments D₂ and T, the arrangement of the segments is similar to that in the corresponding right lobe. The description of the segments and bronchi is also identical.

It may be pointed out that segments V₁ of the right and the left diaphragmatic lobes are the biggest true segments in both lungs except perhaps when compared to some of the composite T-segments.

The Intermediate Lobe

(Figs. 21A, 21B, 32C)

The intermediate lobe has been divided into three segments: D₁, V₁ and T.

Segment D₁

Bronchus D₁ is normally an overdeveloped segmental bronchus (96.87%, Table 6 Fig.). The disproportion between its size and the next bronchus D₂ can be seen in Fig. 21. It runs caudally almost parallel to the stem bronchus of the right lung (Fig. 26A). It supplies an area which in size is about one-third to almost half the size of the lobe, forming its dorso-lateral part which tapers caudally to what has already been called the caudal end of the lobe.

The line of fusion of this segment with the T segment, beginning at the hilum on its dorsal aspect, runs caudally on the dorso-medial surface, crosses the middle of the dorsal border,

runs obliquely across the diaphragmatic surface and then runs through the vena caval notch to end ventral to the hilum.

The segment is projected on the dorso-medial, the right (lateral), and the diaphragmatic surface.

Segment V₁

Bronchus V₁ supplies a variable part of the tongue shaped process of the lobe which lies ventral to the vena caval notch. (Compare Figs. 21A and 32C with Fig. 43) It was found to be overdeveloped in 10 specimens (31.25%) and underdeveloped in 7 specimens (21.87%).

Segment T

The T-segment is larger than or nearly as large as segment D₁. It is projected on the dorso-medial surface, the diaphragmatic surface and the cardiac surface. The whole of the cephalic border, which overlies the "m" bronchi, is situated on it.

It will be noticed from Table 6 that the least variations in size, practically none, are exhibited by the segments of the two diaphragmatic lobes.

Bronchial Supply of Apices

The apices of all left lungs examined were supplied by the terminal part of the lobar stem bronchus of the left apical lobe.

The supply of the right apex was found to be very variable. Only in one lung (Specimen E56) was the apex supplied by the terminal part of the lobar stem bronchus of the right apical lobe. In the remaining specimens it was supplied by a variable number of branches belonging to the D-series of the right apical lobe. The findings are given in Table 7.

It will be seen that in the majority of specimens (27 out of 37) a single bronchus supplied the apex. The bronchi which supplied the apex most frequently are D_4 (16 times) and D_3 (14 times). Thus if, at all, any bronchi deserve being called "apical", they are D_3 and D_4 of the right apical lobe.

On the left side the "apical" bronchus is the lobar stem bronchus itself.

Branches	Apex supplied by a single bronchus				
	D_1	D_2	D_3	D_4	D_5
Number of lobes	2	3	9	9	3
Total	27				

* In these three lobes (specimens) early bifurcation. The apex was supplied by a single bronchus.

Table 7

SUPPLY OF THE RIGHT PULMONARY APEX
(37 Specimens)

Bronchus	Apex supplied by a single bronchus					Apex supplied by more than 1 bronchi					Apex supplied by lobar stem bronchus	No. of times each bronchus supplied the apex										
	D ₁	D ₂	D ₃	D ₄	D ₅	D ₁ , D ₃ , D ₄	D ₄ , D ₅	D ₂ , D ₄	D ₂ , D ₃	D ₃ , D ₄		D ₂ , D ₃ , D ₄	D ₁	D ₂	D ₃	D ₄	D ₅	Lobar stem * bronchus				
Number of Lobes	2	3	9	9	1	3	1	2	2	2	1	1	1	3	8	14	16	3	3	1		
Total	27					9					1											

* In these three lobes (Specimens E7, E33, E53) the lobar stem bronchus underwent an early bifurcation. The apex was supplied by the dorsal of the two branches (Fig. 19).

RUDIMENTARY FISSURES

- Their Relationship to Bronchopulmonary Segments

Apart from the main fissures of the lungs, there were to be found rudimentary fissures, or notches, on a large number of lobes. They varied from being mere notches to well developed clefts, from a few millimetres to about a centimetre or more deep.*

These fissures were situated on the borders of the lobes. In addition, some grooves were present on the surfaces of the lobes, most of them being prolongations of the notches on the borders; their lengths, directions and depths varying considerably. Some of the grooves, independent of the notches, were so faintly marked and irregular in appearance that they were considered insignificant and were ignored.

A total of 60 pairs of lungs, including all those of dog shown in Table I, were examined. In a large number of specimens the relationship of the fissures to segments was determined by actual dissections. In two specimens, used for demonstrating segments by injecting coloured gelatine, it was easy to note the position of these fissures. The remaining specimens were those which were used for preparing bronchial casts. In these the following simple method was used:-

After a pair of lungs was injected, and the injected material was set, the position of each rudimentary fissure was marked by inserting ordinary paper pins into the lung at the depth of the fissure, taking care that the bronchi were not damaged. The

*The majority of the rudimentary fissures were simple notches on the borders. The terms, "rudimentary fissure" and "notch" are used synonymously in this account.

position of these pins, in relation to the bronchial territories, was then noted at the time of washing off the lung tissue softened by maceration in acid. During the process of maceration, lungs were frequently examined to make sure that the washing of the cast was done before the lung tissue was automatically dissolved away by acid and that the pins were in position.

However, due to failures of obtaining casts of some specimens, either of the whole or a part of a pair of lungs, it was not possible to determine the position of each one of the fissures noted. Such lobes, in which it has not been possible to do so, have been omitted in this account. For the same reason, it has not been possible to make observations on each of the seven lobes of the sixty pairs of lungs mentioned above. The total number of each of the seven lobes studied is given below:-

Right apical lobes	49
Right cardiac lobes	60
Right diaphragmatic lobes	50
Intermediate lobes	51
Left apical and cardiac lobes	56 pairs
Left diaphragmatic lobes	49

The findings in each lobe are summarised in Tables 8, 9, 10, 11, 12, and 13.

Table 9

RUDIMENTARY FISSURES OF RIGHT CARDIAC LOBE
(60 lobes)

Site of Notch		No. of Lobes	No. of Notches	
Border	Relation to segments		On Cephalic border	On Caudal border
One on cephalic	Between subsegments of A_1	1	1	-
One on caudal	Between P_2 and T	1	-	1
		2	1	1
No. of lobes exhibiting no notches		58	Total 2	
		60		

Table 10

RUDIMENTARY FISSURES OF RIGHT DIAPHRAGMATIC LOBE
(50 lobes)

	Site of Notch	Relation to segments	No. of Lobes	No. of Notches	
				Hilar notch	On Caudal border
Lobes exhibit- ing one notch each	Hilar notch only	Between D ₁ and V ₁	31	31	-
	One on caudal border	Between V ₁ and V ₂	1	-	1
Lobes exhibit- ing two notches each	One hilar notch; one on caudal border	Hilar notch between D ₁ and V ₁ ; the other between V ₁ and V ₂ .	1	1	1
			33	32	2
No. of lobes exhibit- ing no notches			17	Total = 34	
No. of lobes exhibit- ing no notches			50		

Table 11

RUDIMENTARY FISSURES OF INTERMEDIATE LOBE
(51 lobes)

Site of Notch		No. of Lobes	No. of notches on dorsal border
Border	Relation to segments		
One notch on dorsal border	Between D_1 and T	19	22
	" subsegments of D_1	2	
	" subsegments of T (area D_2)	1	
No. of lobes exhibiting no notches		22	22
		29	
		51	

Table 12.

RUDIMENTARY FISSURES OF LEFT APICAL AND LEFT CARDIAC LOBES
(56 specimens)

No. of Notches	Site of Notch		No. of Lobes	No. of Notches			
	Border	Relation to segments		On lateral fissural border	On dorsal border of apical lobe	On ventral border of apical lobe	On cephalic border of cardiac lobe
Both lobes exhibiting one notch	One on lateral fissural border	Between D ₁ of apical and P ₁ of cardiac lobe	10	10	-	-	-
	One on dorsal border of apical lobe	Between D ₁ and D ₂ of apical lobe	2*	-	2	-	-
	One on ventral border of apical lobe	Between subsegments of T - segment of apical lobe	3	-	-	3	-
	One on cephalic border of cardiac lobe	Between subsegments of T - segment of cardiac lobe	1	-	-	-	1
Both lobes exhibiting two notches	One on lateral fissural border; one on ventral border of apical lobe	One between D ₁ of apical and P ₁ of cardiac lobe; one between subsegments of V ₁ of apical lobe	1	1	-	1	-
	One on ventral border of apical lobe; one on cephalic border of cardiac lobe	One between V ₂ and T of apical lobe; one between subsegments of T segment of cardiac lobe	1	-	-	1	1
	One on lateral fissural border; one on ventral border of apical lobe	One between D ₁ of apical and P ₁ of cardiac lobe; one between subsegments of T-segment of apical lobe	1	1	-	1	-
	One on lateral fissural border; one on cephalic border of cardiac lobe	One between D ₁ of apical and P ₁ of cardiac lobe; one between subsegments of T-segment of cardiac lobe	1	1	-	-	1
	One on dorsal border of apical lobe; one on ventral border of apical lobe	One between D ₁ and D ₂ , and one between subsegments of T segment, of apical lobe	1	-	1	1	-
	One on lateral fissural border; one on cephalic border of cardiac lobe	One between D ₁ of apical and P ₁ of cardiac lobe; one between subsegments of A ₁ of cardiac lobe	1	1	-	-	-
No. of lobes exhibiting no notches			22 34 } 56	14	3	7	4
				Total Number of notches = 28.			

*These two lobes include Specimen E56, illustrated in Fig. 9, in which the notch can be seen to extend almost up to the blind end of the minor fissure so that they appear to meet.

Table 13

RUDIMENTARY FISSURES OF
LEFT DIAPHRAGMATIC LOBE
(49 lobes)

	Site of Notch	Relation to segments	No. of Lobes	No. of Notches	
				Hilar notch	On dorsal border
Lobes exhibit- ing one notch only	Hilar notch	Between D_1 and V_1	39*	39	-
Lobes exhibit- ing two notches each	One hilar notch; one on dorsal border	Hilar notch between D_1 and V_1 ; the other between D_1 and D_2	1	1	1
			40	40	1
	No. of lobes exhibiting no notches		<u>9</u> 49	Total 41	

* These 39 lobes include Specimen E56, illustrated in Fig. 9, in which the hilar notch is continuous with the dorsal part of the major fissure.

Rudimentary Fissures of Right Apical Lobe

Notches were situated either on the dorsal, or on the ventral border. The number of notches per lobe varied from 0 to 4, the details being:-

0 notch	per lobe	12 lobes
1 " " "	"	17 "
2 notches	" "	11 "
3 " " "	"	8 "
4 " " "	"	1 "
		<hr/>
		49

Out of a total number of 67 notches observed, 47 were on the ventral and 20 on the dorsal border (Table 8).

Notches on the Dorsal Border

Analysing from Table 8 , the frequency distribution of the notches on the dorsal border is as follows:-

Between segments P and D ₁	11 notches
" " D ₁ " D ₂	3 "
" subsegments of segment D ₁	2 "
" segments D ₂ and T	1 notch
" segments D ₁ and T (segment D ₂ being a segmentellette-d ₂)	3 notches
<hr/>	
20	

Thus the most frequent notch on the dorsal border marks the plane of separation of segments P and D₁. This notch in all the 11 specimens was situated 1.8 to 3.4 cm. from the dorsal end of the major fissure. One of the two notches, situated between subsegments of segment D₁, was also situated within this range of distance. All other notches were situated cephalic to this range at variable points on the dorsal border.

The three notches between segments D_1 and D_2 were situated very near the apex of the lung. So also were those between segments D_2 and T , and D_1 and T .

Notches on the Ventral Borders

The frequency distribution of the 47 notches on the ventral border, analysed from Table 8, is as follows:-

Between segments P and V_1	29 notches
" subsegments of P segment	2 "
" subsegments of segment V_1	1 notch
" segments V_1 and V_2	4 notches
" subsegments of segment V_2	4 "
" segments V_2 and T	5 "
" subsegments of T segment	2 "
	<hr/>
	47

Thus the most frequent notch on the ventral border is one between segments P and V_1 . This notch in all the 29 lobes was situated at a distance of 1.0 to 3 cm. from the major fissure, with the only exception of two specimens in which the distance was 0.7 cm. (a terrier) and 5.2 cm. (a greyhound). Three other notches which fell within this range of distance were: the notch between subsegments of P segment in two specimens (1.2 cm. and 1.0 cm. from the major fissure), and the notch between subsegments of V_1 segment (2.5 cm. from the major fissure). All other notches were situated cephalic to this level.

Thus the only two notches in the right apical lobe which show a relative constancy of position, and which are relatively present in 32 out of 42 lobes. In all cases the plane between segments D_1 and D_2 .

more frequent than others, are the notches between segments P and D₁ on the dorsal border, and between segments P and V₁ on the ventral border. (Fig. 34) It is interesting to note that they both demarcate the P segment. In 10 lobes out of the 49 examined, the P segment was demarcated by both these notches, and in 2 lobes out of these ¹⁰ the two notches were connected by a deep groove running on the costal surface, so that this segment was completely marked off from the rest of the lobe.

Rudimentary Fissures of Right Cardiac Lobe

The right cardiac lobe was found to be remarkably free from the rudimentary fissures. Only two lobes, out of 60 examined, possessed one notch each. Their positions are indicated in Table .

Rudimentary Fissures of Right Diaphragmatic Lobe

Seventeen lobes were free of any rudimentary fissures.

In the remaining lobes fissures were observed at two sites:-

(1) A rudimentary fissure situated on the fissural surface at the level of the hilum. — In the majority of lobes it was found to commence at the hilum of the lobe. It runs across the fissural surface, crosses the lateral fissural border and ends on the costal surface. Its approximate length, on the costal surface, varies from 1 to 20 mm. (average 9 mm.). In some specimens it remained confined to the fissural surface, and in some others it was represented only as a cleft on the lateral fissural border, without extending up to the hilum.

(Fig. 11B)
This fissure is named the "hilar notch" or fissure. It was present in 32 out of 50 lobes. In all these lobes it marked the plane between segments D₁ and V₁.

(2) A small indent on the caudal border of the lobe. — It was present in two lobes, and marked the plane between segments V_1 and V_2 in each of them. One of these lobes also possessed the hilar notch.

Rudimentary Fissures of the Intermediate Lobe

Rudimentary fissures in the intermediate lobe were found only on the dorsal border. Twenty-nine lobes out of 51 were free of any fissures. It can be seen from Table // that in 19 out of the remaining 22 lobes, possessing a notch on the dorsal border, it was situated between segments D_1 and T, i.e., between territories D_1 and D_2 - territory D_2 being part of T segment. (Fig. 14, 15)

Rudimentary Fissures of the Left Apical and the Left Cardiac Lobes

Rudimentary fissures in these lobes were situated on the dorsal and the ventral borders of the apical lobe, on the cephalic border of the cardiac lobe, and on the lateral fissural border - common to both lobes.

Thirty-four out of 56 specimens were without rudimentary fissures.

The frequency distribution of the total number of 28 notches, observed in these lobes, analysed from Table /2, according to the borders on which they are situated, is given below:-

(1) Lateral fissural border

Between segment D_1 of the apical and segment P_1 of the cardiac lobe

14 notches

(2) Dorsal border of apical lobe

Between segments D_1 and D_2

3 "

(3) Ventral border of apical lobe

Between subsegments of segment V_1	1 notch
Between segments V_2 and T	1 "
Between subsegments of segment T	5 notches

(4) Cephalic border of cardiac lobe

Between subsegments of segment A_1	1 notch
Between subsegments of segment T	3 notches

28

Thus the most frequently occurring notch is between segment D_1 of the apical and segment P_1 of the cardiac lobe. (Fig. 35) This rudimentary fissure, on the lateral fissural border, was constantly situated at the level of the blind end of the minor fissure.

Rudimentary Fissures of the Left Diaphragmatic Lobe

Nine lobes out of 49 were free of rudimentary fissures. The commonest notch, present in all the remaining 40 lobes, as in the corresponding lobe of the right side, was found to be the hilar notch. (Fig. 16B, 35) It constantly marked the plane between segments D_1 and V_1 . Only one of these lobes had an additional fissure situated on the dorsal border between segments D_1 and D_2 .

Summary

The following rudimentary fissures are relatively more constantly present than others, and are of importance in indicating the planes between some of the segments:-

(1) Right apical lobe.

(a) Fissure between segments P and D_1 .

(b) " " " P " V_1 .

(2) Right diaphragmatic lobe.

The hilar notch.

(3) Intermediate lobe.

Fissure between segments D_1 and T.

(4) Left apical and left cardiac lobes.

Fissure between segment D_1 of the apical,
and segment P_1 of the cardiac lobe.

(5) Left diaphragmatic lobe

The hilar notch.

The study also shows that the rudimentary fissures are also situated at subsegmental planes, and that no fissure can, from outward appearance, be taken to represent a certain intersegmental plane with absolute certainty except those mentioned under (2), (4) and (5) above.

It is interesting to note that all these important rudimentary fissures are related to those segments, which are supplied by the first branch of the lobar stem bronchus in each of the lobes in which they are present.

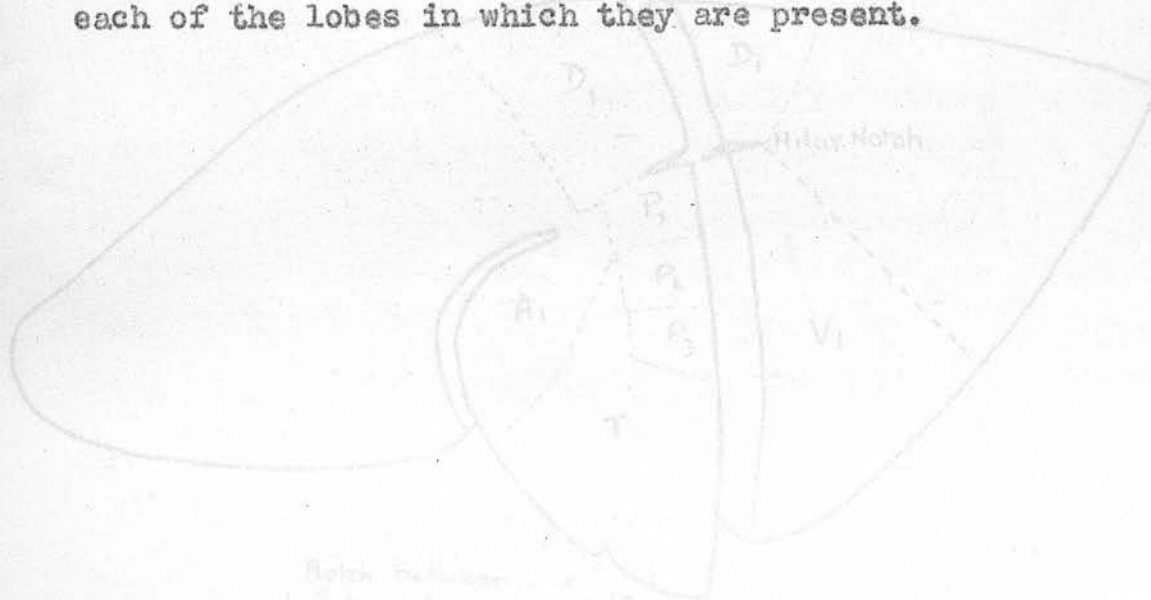
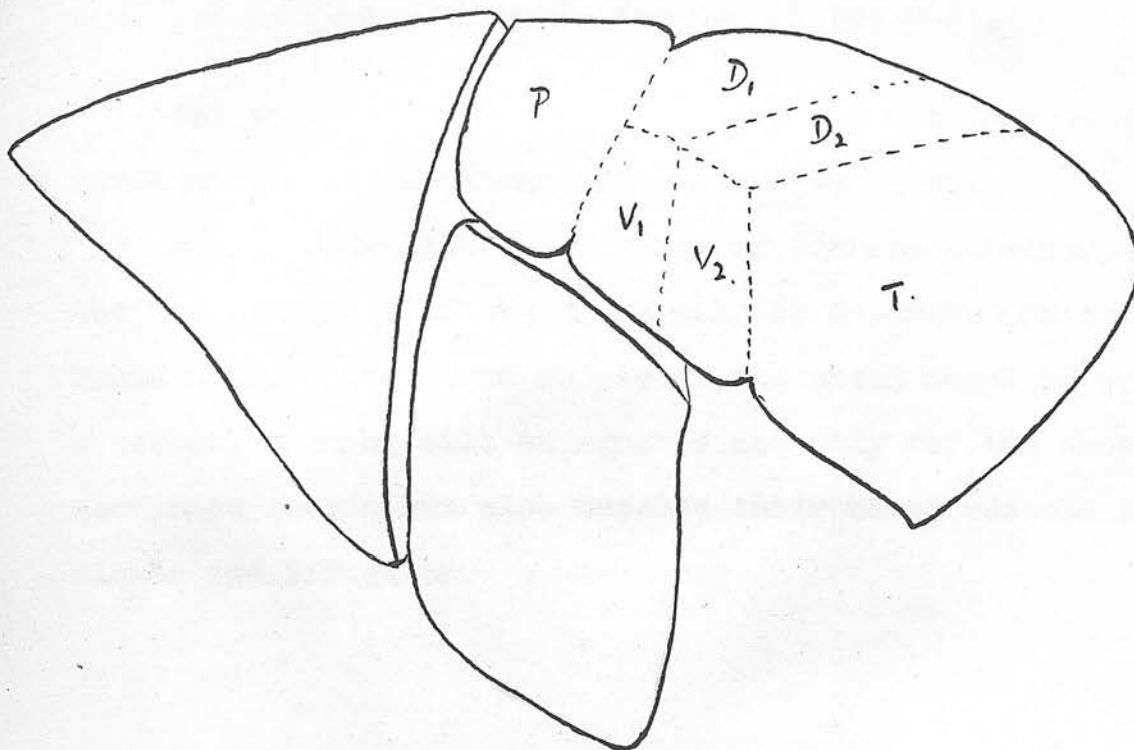


Fig. 35. Drawing of the left lung of dog to show the rudimentary fissures.



BLOOD VESSELS

Fig. 34 . Drawing of the right lung of dog (Specimen E7) to show rudimentary fissures.

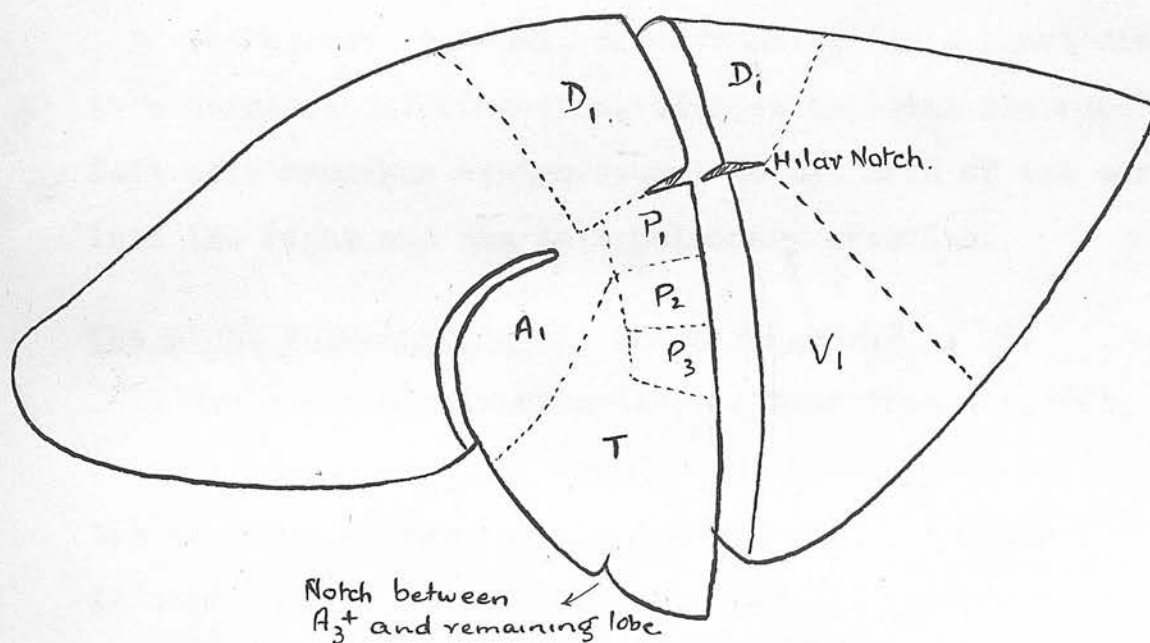


Fig. 35 . Drawing of the left lung of dog (Specimen E53) to show the rudimentary fissures.

BLOOD VESSELS

PULMONARY BLOOD VESSELS OF THE DOG

The study of pulmonary blood vessels was done on 18 specimens, 14 dissections and 4 corrosion casts.

Having established a pattern of broncho-pulmonary segments, the blood vessels of the lobes will be described on segmental basis only. The blood supply of the areas supplied by the accessory bronchi will be ignored not only for the above mentioned reason but also because their blood vessels are minute and irregular.

It crosses the origin of the middle lobe bronchus on its dorso-lateral aspect.

The Left Pulmonary Artery (Figs. 36A, 36B, 37, 39)

The left pulmonary artery runs caudally and dorso-laterally to curve round the cephalic and lateral aspect of the left main bronchus. It then passes dorso-lateral to the common bronchus

PULMONARY ARTERIES

The Pulmonary Trunk

The pulmonary trunk, after running for a short distance, in a dorso-caudal direction, divides opposite the root of the left main bronchus ventro-caudal to the arch of the aorta, into the right and the left pulmonary arteries.

The Right Pulmonary Artery (Figs. 36A, 36B, 37, 39)

The right pulmonary artery, longer than the left, proceeds laterally with a caudal inclination towards the angle between the bronchus of the right apical lobe and the main stem bronchus. In this part of its course it is related dorsally to the caudal end of the trachea, the right stem bronchus at its origin and the proximal end of the right apical lobe bronchus. Ventrally it is related to the cephalic border of the left atrium and both

are crossed by the cephalic vena cava. Just before passing in the angle between the right apical lobe bronchus and the main stem, it passes dorsal to the vein of the right apical lobe as the latter proceeds to the left atrium (Fig. 36). Here the artery lies at the depth of the junction of the major and minor fissures covered by pleura. Thereafter, the artery runs along the lateral aspect of the stem bronchus, still under cover of pleura, to enter the hilum of the diaphragmatic lobe as its lobar artery.

It crosses the origin of the middle lobe bronchus on its dorso-lateral aspect.

The Left Pulmonary Artery (Figs. 36A, 36B, 38, 39)

The left pulmonary artery runs caudally and dorso-laterally to curve round the cephalic and lateral aspect of the left main bronchus. It then passes dorso-lateral to the common bronchus of the left apical and cardiac lobes to reach the lateral aspect of the stem bronchus. It now runs under the pleura at the depth of the major fissure to enter the left diaphragmatic lobe as its lobar artery.

lies between the right main bronchus and the caudal vena cava. It curves round the dorsal aspect of the vena cava, ventro-cephalic to the extra-pulmonary part of the lower bronchus of the right apical lobe; it then passes apical to the neck of vena cava, and running in a dorso-lateral direction enters the cephalic part of the lobar hilum. Occasionally it branches before disappearing into the hilum as shown in Fig. 39.

The Caudal Artery

Smaller than the cephalic artery, it arises from the

BRANCHES OF THE PULMONARY ARTERIES

Only the extra-pulmonary portions of the branches are dealt with in this section. The intra-pulmonary parts are described under respective lobes.

Branches of the Right Pulmonary Artery (Figs. 36A, 36B, 37, 39)

The right pulmonary artery gives off branches successively to the apical, the cardiac, and the intermediate lobes before disappearing into the diaphragmatic lobe.

The majority of right apical lobes examined, details to be given later (page), were supplied by 2 arteries each, the cephalic and the caudal. (For terms "cephalic" and "caudal" see page 147). The cardiac and the intermediate lobes receive one independent artery each. The diaphragmatic lobe is supplied by the continuation of the main arterial trunk.

The Arteries of the Right Apical Lobe

The Cephalic Artery

The cephalic artery, the first branch of the right pulmonary artery (Fig. 36B), originates as the latter artery and lies between the right main bronchus and the cranial vena cava. It curves round the dorsal aspect of the vena cava, ventro-cephalic to the extra-pulmonary part of the lobar bronchus of the right apical lobe; it then passes caudal to the arch of vena azygos, and, running in a dorso-lateral direction, enters the cephalic part of the lobar hilum. Occasionally it branches before disappearing into the hilum as shown in Fig. 39.

The Caudal Artery

Smaller than the cephalic artery, it originates from the

pulmonary artery as the latter passes in the angle between the bronchus of the right apical lobe and the stem bronchus. Here it lies caudal or caudo-ventral to the extra-pulmonary part of the lobar bronchus. It then runs obliquely dorso-laterally caudal to the lobar bronchus to enter the hilum. The artery may be absent.

The Artery of the Cardiac Lobe

As the pulmonary artery crosses the bronchus of the cardiac lobe on its dorso-lateral aspect, it gives off a branch whose origin may slightly precede the lobar bronchus. It accompanys the lobar bronchus on its lateral aspect to enter the hilum immediately.

The Artery of the Intermediate Lobe

A short distance beyond the origin of the artery of the cardiac lobe, the pulmonary artery gives off from its ventro-medial aspect the artery to the intermediate lobe. It runs caudally and medially and, crossing ventral to the stem bronchus, joins the bronchus to the intermediate lobe along its ventro-lateral aspect to enter the lobar hilum.

Branches of the Left Pulmonary Artery

In most of the specimens examined the left pulmonary artery first gives a branch to the left apical and then a branch to the left cardiac lobe. They arise close to each other as the parent trunk crosses dorsal to the common bronchus (Fig. 39). dorsally. Each enters the hilum after a short distance. The continuation of the main artery supplies the diaphragmatic lobe.

Figs. 36 , A. & B.

Drawings to show the structures of the pulmonary roots and hila of the right and the left lungs of Dog - ventral views (Specimen E35) - A, Heart removed leaving dorsal wall of atrium intact; B, Dorsal wall of atrium removed.

- | | |
|--|---|
| 1. Lobar Vein - Right Apical Lobe | 9. Bronchus - Right Diaphragmatic Lobe |
| 1a. Tributary of Lobar Vein - vein D ₁ -D ₂ or D ₁ -d ₂ -T | 10. Bronchus - Intermediate Lobe |
| 1b. Cephalic Vein | 11. Common Bronchus - Left Apical and Cardiac Lobes |
| 1c. Caudal Vein | 12. Bronchus - Left Apical Lobe |
| 2. Lobar Vein - Right Cardiac Lobe | 13. Bronchus - Left Cardiac Lobe |
| 3. Lobar Vein - Right Diaphragmatic Lobe | 14. Bronchus - Left Diaphragmatic Lobe |
| 4. Lobar Vein - Left Apical Lobe | 15. Pulmonary Trunk |
| 5. Lobar Vein - Left Cardiac Lobe | 16. Left Pulmonary Artery |
| 6. Lobar Vein - Left Diaphragmatic Lobe | 17. Right Pulmonary Artery |
| 6a. Vein V ₁ -V ₂ - Left Diaphragmatic Lobe | 18. Cephalic Artery |
| 7. Lobar Vein - Intermediate Lobe | 19. Caudal Artery |
| 8. Bronchus - Right Cardiac Lobe | 20. Lobar Artery - Intermediate Lobe |
| | 21. Bronchus - Right Apical Lobe |
| | T. Trachea |
| | Lt. At. Left Atrium |

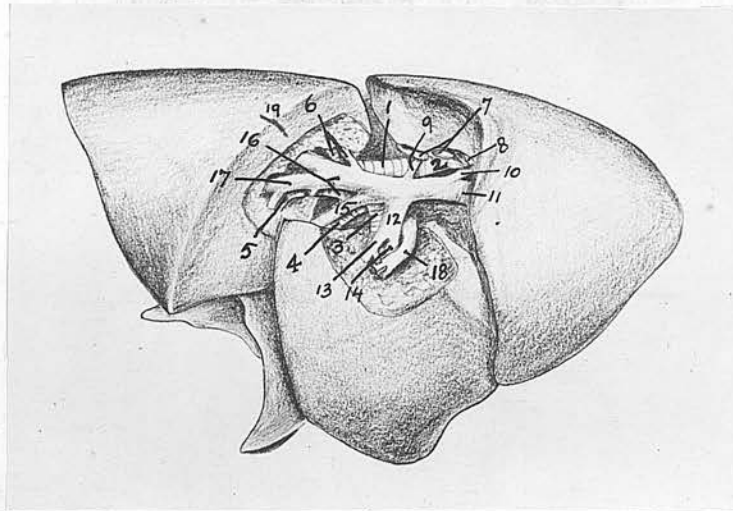


Fig. 37.

Drawing to show the structures of the Pulmonary Root and Hilum of the Right Lung of Dog (Specimen E35), as seen through the Main Fissures (Lobes partially dissected)

- | | |
|--|--|
| 1. Stem Bronchus | 10. Cephalic Artery |
| 2. Bronchus - Apical Lobe | 11. Right Pulmonary Artery |
| 3. Bronchus - Cardiac Lobe | 12. & 14. Lobar Artery - Cardiac Lobe |
| 4. Bronchus - Intermediate Lobe | 13. Artery P_1 of Cardiac Lobe |
| 5. Bronchus V_1 , of Diaphragmatic Lobe | 15. Lobar Artery - Intermediate Lobe |
| 6. Bronchus D_1 and Artery D_1 of Diaphragmatic Lobe | 16. Lobar Artery and Bronchus - Diaphragmatic Lobe |
| 7. Caudal Vein | 17. Artery V_1 - Diaphragmatic Lobe |
| 8. Cephalic Vein | 18. Lateral Vein - Cardiac Lobe |
| 9. Caudal Artery | 19. Hilar Notch |

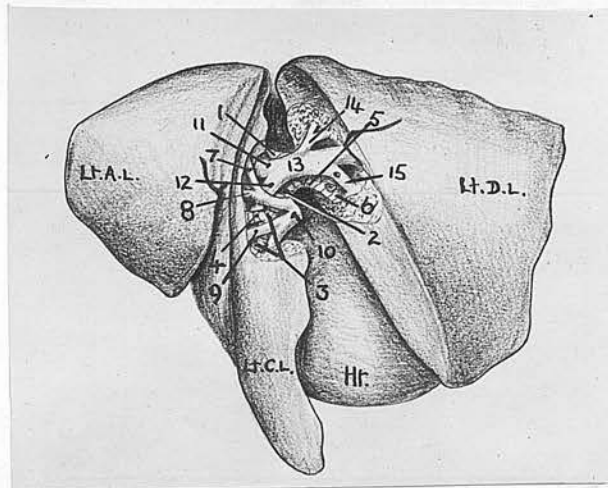


Fig. 38 - Drawing to show the structures of the Pulmonary Root and Hilum of the Left Lung of Dog (Specimen E35)

Drawing to show the structures of the Pulmonary Root and Hilum of the Left Lung of Dog (Specimen E35), as seen through the Major Fissure (Lobes partially dissected)

- | | |
|--|---|
| 1. Left Main Bronchus | 9. Vein P_1 - P_2 - Cardiac Lobe |
| 2. Common Bronchus - Left Apical and Cardiac Lobes | 10. Lobar Vein - Cardiac Lobe |
| 3. Bronchus - Cardiac Lobe | 11. Left Pulmonary Artery |
| 4. Bronchus P_1 - Cardiac Lobe | 12. Lobar Artery - Cardiac Lobe |
| 5. Bronchus - Diaphragmatic Lobe (Stem Bronchus) | 13. Lobar Artery - Diaphragmatic Lobe, continuation of the Pulmonary Artery |
| 6. Bronchus V_1 - Diaphragmatic Lobe | 14. Artery D_1 - Diaphragmatic Lobe |
| 7. Vein D_1 - Apical Lobe | 15. Artery V_1 - Diaphragmatic Lobe |
| 8. Vein D_1 - P_1 | Ht. Heart |
| 8. Bronchus - Left Diaphragmatic Lobe | 20. Lobar Artery - Intermediate Lobe |
| 9. Bronchus - Intermediate Lobe | 21. Outline of Atrium |
| 10. Pulmonary Trunk | Rt.H.F., Lt.H.F. - Right and Left Major Fissures |
| 11. Left Pulmonary Artery | |

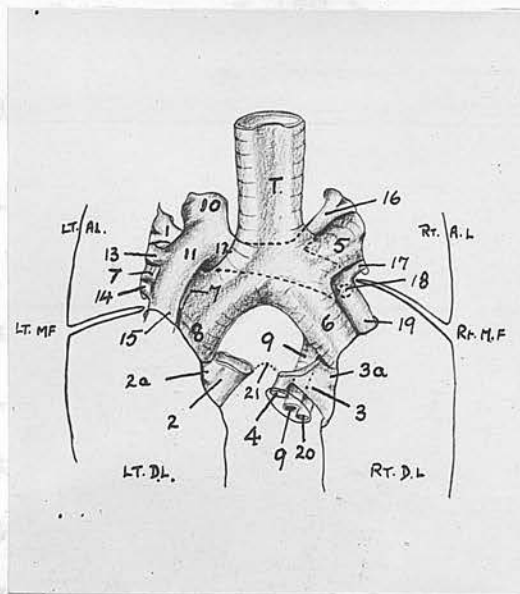


Fig. 39 . Drawing to show the structures of the Pulmonary Roots and Hila of the Right and the Left Lungs of Dog - Dorsal View (Specimen E35)

- | | |
|--|--|
| 1. Lobar Vein - Left Apical Lobe | 12. Right Pulmonary Artery |
| 2. Lobar Vein - Left Diaphragmatic Lobe | 13. Lobar Artery - Left Apical Lobe |
| 2a. Vein D ₁ -D ₂ of Left Diaphragmatic Lobe | 14. Lobar Artery - Left Cardiac Lobe |
| 3. Lobar Vein - Right Diaphragmatic Lobe | 15. Lobar Artery - Left Diaphragmatic Lobe, continuation of Left Pulmonary Artery |
| 3a. Vein D ₁ -D ₂ - Right Diaphragmatic Lobe | 16. Cephalic Artery |
| 4. Lobar Vein - Intermediate Lobe | 17. Caudal Artery |
| 5. Bronchus - Right Apical Lobe | 18. Opening of Lobar Artery - Right Cardiac Lobe |
| 6. Bronchus - Right Diaphragmatic Lobe | 19. Lobar Artery - Right Diaphragmatic Lobe - continuation of Right Pulmonary Artery |
| 7. Common Bronchus - Left Apical and Cardiac Lobes | 20. Lobar Artery - Intermediate Lobe |
| 8. Bronchus - Left Diaphragmatic Lobe | 21. Outline of Atrium |
| 9. Bronchus - Intermediate Lobe | |
| 10. Pulmonary Trunk | Rt.M.F., Lt.M.F. - Right and Left Major Fissures |
| 11. Left Pulmonary Artery | |

GENERAL REMARKS ON THE ARTERIES OF THE LOBES

The arterial pattern in each lobe is almost an exact replica of the bronchial tree. The arteries accompany the bronchi very closely. Each bronchus is accompanied by a single artery.

As a general rule, the area of distribution of a bronchus is supplied by one principal artery. But there are examples in which one to two additional small arteries, arising from the parent artery, supply a part of this area. When more than one artery supply a certain area, each artery is distributed along separate bronchial rami.

Thus each broncho-pulmonary segment is supplied by one principal artery, and in some instances by one or more additional "subsegmental" arteries which supply small subsegmental areas situated close to the lobar stem bronchus.

Similar examples of additional arteries have already been mentioned to exist in both the apical lobes.

When a bronchus is rudimentary, i.e., ^{it} supplies a segment-
ellette and is served by two arteries, each of the two vessels is of about the same size.

No examples were found of arteries crossing the intersegmental planes in the dog's lungs.

ARTERIES OF THE RIGHT APICAL LOBE

It has been noted before that 1, 2 or 3 arteries, arising independently from the pulmonary artery, supply the right apical lobe. The following six types of arrangements were met with:-

I. A lobe was supplied by two arteries. The larger of the two, lying cephalic to the lobar bronchus in the hilum, termed the "cephalic" artery, supplies the whole of the lobe except the P-segment, which is supplied by the smaller artery, termed the "caudal" artery, lying caudal or caudo-ventral to the bronchus. (Figs. 36B, 39 and Plate *I*, Specimen M1) This arrangement was found in 12 lobes.

II. Three arteries were found to supply the lobe in one specimen. The caudal artery supplied the whole of the P-segment, as in Type I, and the cephalic artery supplied the remaining lobe, except segment V_1 which was supplied by an independent artery originating directly from the pulmonary artery between the origins of the cephalic and the caudal arteries (Plate *I*, Specimen M9).

III. The entire lobe was supplied by the single cephalic artery in two lobes. The P-segment was supplied by a branch arising from it just within the hilum ^{which} crossed dorsal to the transverse part of the lobar bronchus in a caudal direction to reach the P-segment. This branch will be referred to as the "recurrent" artery (after Appleton). (Plate *I*, Specimen M4)

IV. Two arteries supplied the lobe in one specimen. The P-segment was supplied by the recurrent artery as in Type III. but the branch to segment V_1 was an independent artery as in Type II.

V. In one lobe the distribution of the cephalic artery was as in Type I. but the caudal artery was represented by two independent arteries, one supplying the dorsal and the other the ventral part of the P-segment. Thus three arteries supplied the lobe (Plate I, Specimen M16).

VI. In one lobe two arteries were found. The caudal artery supplied only the most ventral part of the P-segment; the dorsal part was supplied by a recurrent branch of the cephalic artery (Plate I, Specimen M6).

It will be noticed that two arteries were found in Types I, IV and VI and three arteries in Types II and V but their distributions were different.

The above details, along with the details of specimens, are summarised in Table/4.

Table/4. DETAILS OF THE TYPES OF ARTERIAL SUPPLY OF THE RIGHT APICAL LOBE

Type of Arterial Supply	Details of Arteries and Their Number			No. of Lobes	Details of Specimens
I	Cephalic	- 1	) 2	12	M1, M2, M3, M5, M7, M8, M10, M11, M13, E49, E52, E56.
	Caudal	- 1			
II	Cephalic	- 1	) 3	1	M9
	Caudal	- 1			
	V ₁	- 1			
III	Cephalic with recurrent	- 1	) 1	2	M4, M14
	Caudal	- absent			
IV	Cephalic with recurrent	- 1	) 2	1	E50
	Caudal	- absent			
	V ₁	- 1			
V	Cephalic	- 1	) 3	1	M16
	Caudal	- 2			
VI	Cephalic with recurrent	- 1	) 2	1	M6
	Caudal	- 1			
Total				18	

The Intra-lobar Part of the Cephalic Artery

The cephalic artery runs from the hilum towards the dorsal border of the lobar stem bronchus to cross over to its lateral aspect by passing through one of the proximal dorsal inter-bronchial spaces.

In 9 lobes it passed through the interval between bronchus D_1 and bronchus D_2 (Plate I, Specimen M1), in 8 lobes through the interval between bronchus D_2 and bronchus D_3 . (In Specimen M3 illustrated in Plate II it passes between d_2 and D_3 .) In the remaining single lobe it crossed proximal to the root of bronchus D_1 (Plate II, Specimen M7). In none of the specimens did it cross ventral to the lobar stem bronchus.

Beyond the point of crossing, it runs along the dorso-lateral aspect of the lobar stem bronchus and maintains this relation up to its termination.

The intra-lobar portion of this artery consists of a proximal part before, and a distal part after the point of crossing. The former lies medial and the latter lateral to the origins of the bronchi of the dorsal series.

The number of branches arising from the proximal part of the artery varies and depends upon the point at which the artery crosses the lobar stem bronchus (Table 15).

The courses of the branches of the cephalic artery are also influenced by the point of crossing^{of} the lobar stem bronchus and will be described under segmental arteries.

The manner in which the cephalic artery gives off branches after having crossed the stem bronchus, is relatively simple. As it runs along the dorso-lateral border of the lobar bronchus, it gives off an artery to accompany each of the D-series of bronchi.

Table 15 *

THE SEGMENTAL ARTERIES ARISING BEFORE THE CEPHALIC ARTERY CROSSES THE LOBAR STEM BRONCHUS

Site at which the Cephalic Artery crosses the lobar stem bronchus	Branches arising before crossing the Lobar Stem Bronchus		No. of Lobes	Details of Specimens
	No. of Branches	Details of branches in the order in which they arise		
Proximal to root of bronchus D_1	1	D_1	1	M7
Interspace $D_1 - D_2$	1	D_1	8	M1, M4, M5, M6, M10, M11, M16, E49.
	2	D_1, V_1	1	E52
Interspace $D_2 - D_3$	3	D_1, V_1, D_2	4	M2, M8, M3, E56
	3	D_1, D_2, V_2	1	M9
	4	D_1, V_1, V_2, D_2	3	M13, M14, E50.

* Note: In Specimens M4, M6, M14 and E50, artery D_1 was preceded by the origin of the recurrent artery, not indicated in the above table.

Each ventral artery crosses the lateral aspect of the stem bronchus to meet and accompany its corresponding bronchus. These arteries run along the lateral aspects of their respective bronchi.

The Intra-lobar Part of the Caudal Artery

It has been seen that the caudal artery in most lobes (13 out of 18, 12 conforming to Type I, and 1 to Type II) supplied the whole of the P-segment.

In one lobe (Type V) it was "split" into two rami which supplied the whole of P-segment.

In three lobes (Types III and IV) it was absent and entirely replaced by the recurrent artery.

In one lobe (Type VI) it was only partly replaced by the recurrent artery.

In its intra-lobar course the caudal artery was found to be distributed along the fissural aspect of the bronchial rami, but the terminal branches tend to run on the costal aspect of the bronchi.

Arterial Supply of Individual Segments

Segment P

The arterial supply of this segment has been described in detail under the six types of arterial arrangements and under the caudal artery.

Segment D₁

In 17 lobes out of 18, in which the cephalic artery passed medial to the root of bronchus D₁, the segmental artery D₁ originated medial to its root. In each of these specimens it gradually crossed the segmental bronchus on its medial aspect to gain its dorsal border. Its branches tend to gain the lateral aspect of the bronchial rami.

In the remaining single lobe in which the cephalic artery

crossed proximal to the root of bronchus D_1 , the artery arose caudal to the root of the bronchus (Plate II, Specimen M7).

Additional Arteries

Additional small arteries for this segment were found in 7 out of 18 lobes. In 5 of these (Specimens M2, M4, M8, M14, E49) this branch originated from artery V_1 (Plate III, Specimen M2), and supplied the first lateral subsegment of segment D_1 . In the remaining 2 specimens (M6, M11) this additional branch arose from the cephalic artery close to and distal to the main segmental artery, and supplied the adjoining area (Plate I, Specimen M6).

Segment D_2

The segmental artery D_2 is related to the stem of bronchus D_2 on its lateral or on its medial side, depending upon whether the cephalic artery passes lateral or medial to the bronchus. (Compare Specimens M1 and M9 in Plate I.) The terminal branches are, however, related to the lateral aspect of bronchial rami.

Additional Arteries

Segment D_2 was supplied by 2 arteries in 8 lobes: in 7 of these (Specimens M3, M4, M6, M10, M11, E49, E50), segment D_2 was a segmentellette. Both arteries were small and of variable size. In the 8th lobe it was a fully developed segment and the additional artery originated proximal to the origin of the principal segmental artery and supplied a small adjoining area (Plate III, Specimen E52).

In another single lobe the segment was a segmentellette and was supplied by 3 arteries, one of them being a branch of

artery V_2 (Plate II, Specimen M13).

Segment V_1 (Plate IV, Specimen E7).

In 8 lobes (Specimens M1, M4, M5, M6, M10, M11, M16, E49) artery V_1 originated as the cephalic artery emerged on the lateral side after crossing the lobar stem bronchus between bronchi D_1 and D_2 (Plate III, Specimen M1). It crossed lateral to the lobar bronchus to meet the corresponding bronchus.

In one lobe (Specimen E52) artery V_1 originated as the first branch of the cephalic artery soon after the latter's origin from the pulmonary artery (Plate III, Specimen E52). It passed ventral to the lobar bronchus to reach the caudal border of the corresponding bronchus and wound round it to gain its lateral aspect.

In 5 lobes (Specimens M2, M8, M13, M14, E56) artery V_1 originated from the cephalic artery as the latter passed opposite interbronchial space $D_1 - D_2$ (Plate II, Specimen M13). Artery V_1 traversed space $D_1 - D_2$ and, after crossing the lateral aspect of lobar bronchus, reached bronchus V_1 .

In one lobe (Specimen M3) artery V_1 crossed the dorsal aspect of lobar bronchus by passing proximal to bronchus D_1 , and then crossed the lateral side of lobar bronchus to reach bronchus V_1 (Plate II, Specimen M3).

In 2 lobes (Specimens M9 and E50) artery V_1 arose independently from the pulmonary artery and passed ventro-medial to the lobar bronchus to reach bronchus V_1 to supply the segment (Plate I, Specimen M9).

In the remaining single lobe (Specimen M7) the artery

originated from the cephalic artery as the latter passed lateral to the root of bronchus D₁ after having crossed proximal to bronchus D₁ (Plate II, Specimen M7).

In none of the lobes was this segment supplied by any additional artery.

Segment V₂

In 14 lobes (Specimens M1, M2, M3, M5, M6, M7, M8, M10, M11, M16, E49, E52, E56) artery V₂ originated after the cephalic artery had crossed the lobar stem bronchus. It then crossed the latter to reach the corresponding bronchus to supply the segment (Plate II, Specimens M3, M7; Plate III, Specimen M1).

In 4 lobes (Specimens M9, M13, M14, E50) artery V₂ was found to originate before the crossing of the cephalic artery. In 3 lobes it traversed interbronchial space D₁-D₂ to cross the lobar bronchus on its lateral side to reach bronchus V₂ (Plate II, Specimen M13). But in the 4th specimen it passed obliquely medial to the lobar bronchus to reach the corresponding bronchus (Plate I, Specimen M9).

Additional Arteries

Only in 1 out of 18 lobes was this segment supplied by an additional artery, and in this specimen it was a segmentallete (Plate II, Specimen M7).

Segment T

Segment is supplied by the continuation of the cephalic artery.

The findings with regard to the number of arteries supplying each segment, in each of the lobes examined, are summarised in Table /6 .

Table /6

NUMBER OF ARTERIES SUPPLYING EACH SEGMENT
OF THE RIGHT APICAL LOBE

Segments and the No. of Arteries					Details of Specimens	No. of Lobes
P	V ₁	V ₂	D ₁	D ₂		
1	1	1	1	1	M1, M5, M9, E56	4
1	1	1	2	1	M2, M8, M14	3
1	1	1	1	2	M3, M10, E50, E52	4
1	1	1	2	2	M4, M11, E49	3
2	1	1	2	2	M6	1
1	1	2	1	-	M7	1
1	1	1	1	3	M13	1
2	1	1	1	1	M16	1
					Total	18

lobes (Specimen M14) in which bronchi P₁ and V₁ arose by a common stem, the corresponding arteries also had a common stem of origin. Artery P₁ in this specimen ran on the fissural aspect of bronchus P₁. In 11 lobes it ran along the lateral aspect of bronchus P₁. In the remaining six it ran along the proximal (dorsal) border of the bronchus and then turned either on to its lateral or medial aspect by passing between the dorsal subsegmental branches.

Additional arteria - In 4 lobes out of 7 (Specimens M4, M7, M13) in which this segment was supplied by two arteries the proximal one was the smaller artery which was the subsequent; the distal artery was the larger one.

ARTERIES OF THE RIGHT CARDIAC LOBE

Each lobe was found to be supplied by a single artery traceable as far as the lobar stem bronchus could be traced.

In its intrapulmonary course the artery closely accompanies the lateral aspect of the lobar stem bronchus between the cephalic and the caudal series of bronchi.

In one lobe (Specimen M6) the artery passed through inter-bronchial space $P_3 - P_4$ to continue its remaining course by running caudal to the lobar stem bronchus medial to the roots of bronchi of P series. In another specimen in which bronchi P_1 and A_1 originated by a common stem, the artery passed medial to bronchus P_1 (Plate IV, Specimen M14).

The artery gives off a principal branch to accompany each of the bronchi as it passes by their roots.

The Segmental Arteries (Plate IV, Specimen M2)

Segment P_1 - Artery P_1 originated either opposite or slightly distal to the root of bronchus P_1 in 17 lobes. In one lobe (Specimen M14) in which bronchi P_1 and A_1 arose by a common stem, the corresponding arteries also had a common stem of origin. Artery P_1 in this specimen ran on the fissural aspect of bronchus P_1 . In 11 lobes it ran along the lateral aspect of bronchus P_1 . In the remaining six it ran along the proximal (dorsal) border of the bronchus and then turned either on to its lateral or medial aspect by passing between the dorsal subsegmental branches.

Additional Arteries - In 4 lobes out of 5 (Specimens M3, M4, M7, M13) in which this segment was supplied by 2 arteries, the proximal one was the smaller artery which supplied a small subsegment; the distal artery was the principal artery. In

the 5th lobe (Specimen E52) 3 arteries supplied this segment. The principal artery was situated between the 2 small arteries.

Segment P₂

In all lobes artery P₂ originated opposite bronchus P₂ and accompanied the corresponding segmental bronchus on its lateral aspect, except in one (Specimen M13) in which it turned to the medial aspect by turning round the dorsal border of the segmental bronchus.

Additional Arteries

Out of 16 lobes, in which segment P₂ was supplied by additional arteries, in 12 there was one, and in 4 lobes 2 additional arteries in each - all arising proximal to the origin of the principal segmental artery.

Segment A₁

In one lobe (Specimen M14), already mentioned under segment P₁, artery A₁ had a common origin with artery P₁. It passed of bronchi P₁ and A₁ dorsal to the common stem/and was then distributed along the lateral aspect of bronchus A₁ as in the remaining 17 lobes.

Additional Arteries

In 3 lobes only, out of 18, was an additional artery present. In 2 (Specimens E50, E56) the additional artery arose proximal and in one lobe (Specimen M5) it arose distal to the main segmental artery.

Segment A₂

Artery A₂ originated opposite bronchus A₂, and accompanied it in all lobes along its lateral aspect.

Additional Arteries

In 2 lobes (Specimens M4, E49), in which the segment was supplied by an additional artery, it originated proximal to the main segmental artery in each.

Segment T

The T-segment is supplied by the continuation of the lobar artery.

The findings with regard to the number of arteries supplying each segment in each of the lobes examined are summarised in Table 17.

Table 17

NUMBER OF ARTERIES SUPPLYING EACH SEGMENT OF THE RIGHT CARDIAC LOBE

Segments and the No. of Arteries				Details of Specimens	No. of Lobes
P ₁	P ₂	A ₁	A ₂		
1	2	2	1	M5	1
1	3	2	1	E50, E56	2
3	2	1	1	E52	1
1	1	1	2	E49	1
1	3	1	1	M14 (Common origin of arteries P ₁ and A ₁)	1
1	2	1	1	M1, M2, M16, M8, M9, M10, M11.	7
2	2	1	1	M3, M7	2
1	3	1	1	M6	1
2	2	1	2	M4	1
2	1	1	1	M13	1
				Total	18

ARTERIES OF THE RIGHT DIAPHRAGMATIC LOBE

Each of the 18 lobes examined was supplied by the continuation of the main right pulmonary artery.

In all lobes, except one (Specimen E50 - see Footnote), the artery was traceable as far as the lobar bronchus was traceable.

In its intrapulmonary course the artery closely accompanies the lobar bronchus. It is at first lateral to it and then gradually turns to the dorsal aspect in the distal part of the lobe. It runs between the two main series of bronchi. It gives off one principal artery to accompany each of the branches of the lobar stem bronchus.

The Segmental Arteries (Plate IV, Specimen M3)

Segment D₁ - Artery D₁ was found to originate in all the lobes either opposite or slightly proximal to the origin of the corresponding bronchus at or just within the hilum. (Fig. 37) It is related to the lateral or cephalic aspect of the proximal part of the segmental bronchus, and is distributed along the fissural (cephalic) aspect of the branches of bronchus D₁.

Additional Arteries - In two lobes (Specimens M4, E50) an additional artery supplied segment D₁. In each its origin was distal to the principal segmental artery.

Segment D₂ - Artery D₂ originated in all the lobes either opposite or slightly proximal to bronchus D₂, and accompanied the segmental bronchus on its lateral aspect. Its main

Footnote: In specimen E50 the lobar artery terminated by dividing into arteries D₄ and V₃, so that the rest of the lobar stem bronchus was unaccompanied by an artery. Both these terminal arteries end into tufts of multiple varicose branches under the pleura. This anomaly was not recognised before injecting the lungs.

branches were distributed either along the cephalic or the caudal aspect of the rami of bronchus D₂.

Additional Arteries - In 8 lobes (Specimens M2, M4, M5, M6, M7, M9, M13, M16) an additional small artery supplied segment D₂. In 3 lobes it was distal, and in the remaining 5 lobes proximal to the principal segmental artery.

(Fig. 37)

Segment V₁ -/Artery V₁ was found to originate in all the lobes opposite or slightly proximal to the root of the corresponding bronchus. It was distributed in all lobes along the lateral aspect of the bronchial rami.

Additional Arteries - Only in one lobe (Specimen M16) was the segment supplied by an additional artery which originated distal to the principal artery.

Segment V₂ - Artery V₂ originated opposite the root of bronchus V₂ in all except 2 lobes, in one of which it was proximal and in the other distal to it. In all the lobes it ramified along the lateral aspect of bronchial branches.

Additional Arteries - Seven lobes (Specimens M4, M9, M10, M13, M14, M16, E56) were supplied by an additional artery, in each of which the additional artery originated proximal to the principal artery.

Segment T - The T-segment is supplied by the continuation of the lobar artery.

The findings with regard to the number of arteries, supplying each segment in each lobe examined, are set out in Table 18.

Table 18

NUMBER OF ARTERIES SUPPLYING EACH SEGMENT
OF THE RIGHT DIAPHRAGMATIC LOBE

Segments and the No. of Arteries				Details of Specimens	No. of Lobes
D ₁	D ₂	V ₁	V ₂		
1	2	1	2	M9, M13	2
1	2	1	1	M2, M5, M6, M7	4
2	2	1	2	M4	1
1	1	1	1	M1, M3, M8, M11, E49, E52	6
1	1	1	2	M10, M14, E56	3
1	2	2	2	M16	1
2	1	1	1	E50	1
					<hr/> 18

bronchus V₁.

Segment V₁ - In 5 lobes (specimens M4, M7, M10, M11, E52) segment V₁ was a segmentallette and in 4 out of these (specimens M4, M7, M10, M11) it was supplied by a tiny branch which originated opposite the root of bronchus V₁ from the lobar artery. In the 5th lobe (specimen E52) the artery to V₁ arose from artery V₂, as the latter ran past the root of bronchus V₁.

In 13 lobes (specimens M1, M2, M3, M5, M6, M8, M9, M13, M14, M16, E49, E50, E56) artery V₁ was large and originated opposite the root of bronchus V₁ to be distributed along the diaphragmatic aspect of the bronchial tree.

In 2 lobes out of the 13 mentioned above, in which V₁ was an additional small artery supplied the area of the first lateral branch of bronchus V₁.

The number ARTERIES OF THE INTERMEDIATE LOBE in each of the lobes examined are shown in Table 17.

A single artery supplies each lobe, which accompanies the lobar stem bronchus up to its termination.

The artery enters the hilum ventro-lateral to the lobar bronchus and then winds round the lobar stem bronchus to gradually occupy a position along its diaphragmatic aspect between the dorsal and the ventral series of bronchi.

The Segmental Arteries (Plate IV, Specimen M5)

Artery D_1

Segment D_1 - / runs along the ventral, ventro-lateral or ventro-medial aspect of the stem of bronchus D_1 . Only in one lobe (Specimen M14) was the segment supplied by an additional artery, proximal to the main segmental artery, which supplied a very small area supplied by the first lateral branch of bronchus D_1 .

Segment V_1 - In 5 lobes (Specimens M4, M7, M10, M11, E52) segment V_1 was a segmentellette and in 4 out of these (Specimens M4, M7, M10, M11) it was supplied by a tiny branch which originated opposite the root of bronchus V_1 from the lobar artery. In the 5th lobe (Specimen E52) the artery to V_1 arose from artery V_2 , as the latter ran past the root of bronchus V_1 .

In 13 lobes (Specimens M1, M2, M3, M5, M6, M8, M9, M13, M14, M16, E49, E50, E56) artery V_1 was large and originated opposite the root of bronchus V_1 to be distributed along the diaphragmatic aspect of the bronchial rami.

In 2 lobes out of the 13 mentioned above, (Specimens M2, M6), an additional small artery supplied the area of the first lateral branch of bronchus V_1 .

The number of arteries supplying each segment in each of the lobes examined are shown in Table 19.

Table 19

NUMBER OF ARTERIES SUPPLYING THE SEGMENTS
IN THE INTERMEDIATE LOBES

Segments and the No. of Arteries	Details of Specimens	No. of Lobes
D ₁ V ₁		
2 1	M14	1
1 2	M2, M6	2
1 1	M1, M3, M4, M5, M7, M8, M9, M10 M11, M13, M16, E49, E50, E52, E56	15
	Total	18

ARTERIES OF THE LEFT APICAL AND THE LEFT CARDIAC LOBES

A separate artery supplied each of the apical and the cardiac lobes in 14 specimens (Fig.39; Plate V, Specimen M6).

In 3 specimens (Specimens M5, M10, M14) the segmental artery D_1 of the apical lobe originated independently from the pulmonary artery and served as an additional artery to the lobe. In these specimens it was situated between the lobar artery of the apical and of the cardiac lobes (Plate V, Specimen M10). In one lobe the 2 lobar arteries had a common origin from the pulmonary artery (Plate V, Specimen M8).

ARTERIES OF THE LEFT APICAL LOBE

The lobar artery in each lobe was traceable up to the termination of the lobar stem bronchus.

As in the right apical lobe, the lobar artery crosses the lobar stem bronchus on its dorsal aspect from the medial to the lateral side, and then follows it along its lateral or dorso-lateral aspect. Beyond the point of crossing, it runs between the origins of the dorsal and the ventral series of bronchi. In 12 lobes this crossing took place in the interbronchial space $D_1 - D_2$ (Plate V, Specimens M6, M10), in 4 in space $D_2 - D_3$ (Plate V, Specimen E49), and in one (Specimen M9) in space $D_3 - D_4$. In one lobe (Plate V, Specimen M8), the common stem of the artery of the apical and of the cardiac lobe passed through space $D_1 - D_2$ before dividing into the two respective lobar arteries. In none of the lobes the crossing took place ventral to the lobar stem bronchus.

The lobar artery gives off one principal artery to accompany each branch of the lobar stem bronchus.

The details of branches, arising from the lobar artery before it crosses the lobar stem bronchus in each lobe, are given in Table 20.

Table 20

THE SEGMENTAL ARTERIES ARISING BEFORE THE LOBAR ARTERY CROSSES THE LOBAR STEM BRONCHUS

Site at which the Lobar Artery crosses the Lobar Stem Bronchus	No. of Branches	Details of branches in the order in which they arise	No. of Lobes	Details of Specimens
Interspace $D_1 - D_2$	1	D_1	12	M1, M3, M4, M5, M6, M10, M11, M13, M14, M16, E50, E56.
Interspace $D_1 - D_2$ traversed by common stem of arteries of apical and cardiac lobes	0	-	1	M8
Interspace $D_2 - D_3$	2	D_1, D_2	1	E52
	3	D_1, V_1, D_2	3	M2, M7, E49
Interspace $D_3 - D_4$	5	D_1, V_1, D_2, V_2, D_3	1	M9

The Segmental Arteries

Segment D_1 - In 17 out of 18 lobes, the segmental artery D_1 and its principal ramifications were related to the medial aspect of the corresponding bronchus.

In the 18th lobe (Plate V, Specimen M8), in which the artery originated from the artery of the cardiac lobe, it was related to the cephalic aspect of the root of the segmental bronchus, but its branches were distributed along the lateral aspect of bronchial rami.

Additional Arteries - A small additional artery supplied this segment in 3 lobes (Specimens M2, M4, M7). In 2 of these lobes (Specimens M2, M4), the additional artery arose distal to the main segmental artery and supplied a small subsegment. In the 3rd lobe (Specimen M7), the additional artery originated from artery V_1 , the latter arising so close to artery D_1 that they appeared to have a common origin.

Segment D_2 - The relation of artery D_2 to its corresponding bronchus depends upon the side on which the lobar artery passes the segmental bronchus. In the 13 lobes, in which the lobar artery passed through interbronchial space $D_1 - D_2$ and then on the lateral side of bronchus D_2 , the artery was related to the lateral aspect of the segmental bronchus. In the remaining lobes the lobar artery passed medial to bronchus D_2 , so that the segmental artery was related to the medial aspect of the bronchus.

Additional Arteries - Segment D_2 was supplied by 2 additional arteries in 3 lobes. In one of these lobes (Specimen M2) the segment was rudimentary and 3 equal sized small arteries supplied it. Out of the remaining 2, in one (Specimen M4) the additional arteries arose distal, and in the other (Specimen M5) proximal to the main segmental artery.

In 4 other specimens, segment D_2 was supplied by one

additional artery. In 2 of these (Specimens M10, M16) the additional artery arose proximal, and in the remaining 2 (Specimens E50, E56) distal to the principal segmental artery.

Segment D₃ - In all lobes, except one (Specimen M9) in which the lobar artery passed through space D₃ - D₄ and was related to the medial aspect of the bronchus, the segmental artery was related lateral to the segmental bronchus.

Additional Arteries - One additional artery was found in 6 lobes (Specimens M2, M4, M6, M7, M13, E50). In 2 of these (Specimens M4, M7), bronchus D₃ supplied a segmentellette and 2 equal sized small arteries supplied it. In 3 (Specimens M2, M6, M13), the additional artery arose proximal, and in the remaining one (Specimen E50) distal to the main segmental artery.

In one lobe (Specimen M3), 3 small arteries supplied the segment which was a segmentellette.

Segment V₁ - In 3 of the 4 lobes (Specimens M2, M7, E49), in which the crossing of the lobar artery took place through interbronchial space D₂ - D₃, artery V₁ arose from the lobar artery opposite the space D₁ - D₂, which it traversed to cross lateral to the lobar stem bronchus, to meet and accompany the corresponding segmental bronchus (Plate V, Specimen E49).

In the single lobe in which the crossing of the lobar artery took place at interbronchial space D₃ - D₄ (Specimen M9), the artery crossed medial to the lobar stem bronchus to accompany the segmental bronchus along its medial aspect. In all other lobes, artery V originated after the lobar artery had crossed over to the lateral aspect of the lobar bronchus, and was

related to the lateral side of the segmental bronchus.

No additional arteries were found.

Segment V₂ - In one specimen (Specimen M9), in which the crossing of the lobar artery took place in interbronchial space D₃ - D₄, the segmental artery V₂ originated before the crossing had taken place. The artery was distributed along the medial aspect of the segmental bronchus.

In the remaining 17 lobes, artery V₂ was given off after the lobar artery had crossed the lobar stem bronchus. In one of these (Specimen E56) its origin was in common with artery V₃. The artery was, in these specimens, related to the lateral aspects of the segmental bronchi.

No additional arteries were found for this segment in any of the specimens.

Segment T - The T-segment is supplied by the continuation of the lobar artery.

It may be noted that in specimen M9, in which the lobar artery crossed the lobar stem bronchus in space D₃ - D₄, all segmental arteries originated from the lobar artery proximal to its point of crossing and were distributed along the medial aspects of the respective bronchi.

The number of arteries supplying each segment in each lobe examined is given in Table 2/ .

ARTERIES OF THE RIGHT CARDIAC LOBE
Table 21
NUMBER OF ARTERIES SUPPLYING EACH SEGMENT
IN THE LEFT APICAL LOBES

Segments and the No. of Arteries					Details of Specimens	No. of Lobes
D ₁	D ₂	D ₃	V ₁	V ₂		
2	3	2	1	1	M2, M4	2
1	1	3	1	1	M3	1
1	3	1	1	1	M5	1
1	1	2	1	1	M6, M13	2
2	1	2	1	1	M7	1
1	2	1	1	1	M10, M16, E56	3
1	2	2	1	1	E50	1
1	1	1	1	1	M1, M8, M9, M11, M14, E49, E52.	7
					Total	18

of the apical lobes.

The Segmental Arteries

All the segmental arteries were found to arise at the levels of the origins of the respective bronchi, with a few exceptions (such as arteries P₂ and P₃ in Specimens E49, E56, in which the origins were a little proximal to the origins of the corresponding bronchi.)

All arteries were related to the lateral aspects of bronchi throughout their courses.

The T-segment was supplied by the continuation of the lobar artery.

ARTERIES OF THE LEFT CARDIAC LOBE

Each of the 18 lobes examined was supplied by a single artery which closely accompanies the lateral aspect of the lobar stem bronchus between the caudal and the cephalic series of bronchi as in the right cardiac lobe. In each lobe it was traceable up to the termination of the lobar stem bronchus. In one lobe (Specimen M1) it passed through interbronchial space $P_3 - P_4$ to run the rest of its course along the medial aspects of roots of the caudal series of branches under the fissural surface for the diaphragmatic lobe. (Compare with the course of the lobar artery in Specimen M6 in right cardiac lobe, on page 156.)

It gives off branches to accompany the bronchi as it passes by their roots.

In one lobe (Plate V, Specimen M8), as already mentioned, the lobar artery had a common stem of origin with the artery of the apical lobe.

The Segmental Arteries

All the segmental arteries were found to arise at the levels of the origins of the respective bronchi, with a few exceptions (such as arteries P_2 and P_3 in Specimens E49, E56, in which the origins were a little proximal to the origins of the corresponding bronchi.)

All arteries were related to the lateral aspects of bronchi throughout their courses.

The T-segment was supplied by the continuation of the lobar artery.

Additional Arteries

Segment P₁ - In each of the 5 lobes (Specimens M3, M13, M14, E49, E50) this segment was supplied by an additional artery. In each its origin was proximal to the principal segmental artery.

Segment P₂ - An additional artery supplied this segment in 3 lobes (Specimens M9, M16, E56). In one (Specimen M9) it was small and originated proximal to the principal artery, in one (Specimen E56) distal, and in the third (Specimen M16) at the same level as the principal artery.

Segment P₃ - In 5 lobes (Specimens M2, M3, E50, E52, E56) an additional artery supplied this segment. In one (Specimen M2) the additional artery arose from the artery m₁ (the artery to area supplied by accessory bronchus m₁), as it passed caudal to the lobar stem bronchus in the angle formed by bronchus P₃.

In 3 lobes (Specimens M3, E50, E52), the additional artery originated proximal to the principal artery.

In one lobe (Specimen E56) segment P₃ was a segmentellette and was supplied by 2 small arteries of about the same size.

Segment A₁ - Only in one lobe (Specimen M7) was an additional small artery found. It originated proximal to the principal segmental artery.

The number of arteries supplying each segment, in 18 lobes examined, is given in Table 22.

ARTERIES OF THE DIAPHRAGMATIC LOBE Table 22

NUMBER OF ARTERIES SUPPLYING EACH SEGMENT
OF THE LEFT CARDIAC LOBE

Segments and the No. of Arteries				Details of Specimens	No. of Lobes
P ₁	P ₂	P ₃	A ₁		
1	1	1	1	M1, M4, M5, M6, M8, M10, M11	7
1	1	2	1	M2, E52	2
2	1	2	1	M3, E50	2
1	1	1	2	M7	1
1	2	1	1	M9, M16	2
2	1	1	1	M13, M14, E49	3
1	2	2	1	E56	1
Total					18

At its origin, therefore, it was either lateral or slightly cephalic to the root of the bronchus. In the majority of specimens its branches soon turned to the cephalic aspect of the bronchus, and ramified along the cephalic aspect of the bronchial rami.

Additional Arteries - An additional artery was found in 3 specimens. In 2 (Specimens M4, M16), it was found to be the main segmental artery, and in one (Specimen E56) it was

Segment D₂ - The origin of artery D₂ was found to be at the root of bronchus D₂ or a little proximal to it. The artery ramified in the majority of cases to the cephalic aspect of the branches of bronchus D₂. In the remaining 3 lobes, the main branches were

ARTERIES OF THE LEFT DIAPHRAGMATIC LOBE

Each lobe, as in the case of the right diaphragmatic lobe, is supplied by the continuation of the left pulmonary artery.

In all lobes the artery was traceable up to the termination of the lobar stem bronchus.

Its intrapulmonary course is identical to that of the corresponding artery of the right side. It is at first lateral to the lobar stem bronchus but gradually shifts to its dorsal aspect in the distal part of the lobe. It gives off a principal artery to each of the bronchi as it passes their roots.

The Segmental Arteries (Plate IV, Specimen M3)

Segment D₁ - Artery D₁ originates either opposite or slightly proximal to the origin of the corresponding bronchus. At its origin, therefore, it was either lateral or slightly cephalic to the root of the bronchus. In the majority of specimens its branches soon turned to the cephalic aspect of the bronchus, and ramified along the cephalic aspect of the bronchial rami.

Additional Arteries - An additional artery was found in 3 specimens. In 2 (Specimens M4, M16), it was distal to the main segmental artery, and in one (Specimen E52) proximal to it.

Segment D₂ - The origin of artery D₂ was either opposite the root of bronchus D₂ or a little proximal to it. The artery ramified in the majority of cases along the cephalic aspect of the branches of bronchus D₂ (15 out of 18). In the remaining 3 lobes, the main branches were either caudal or

lateral to the main bronchial ramification.

Additional Arteries - In 7 lobes, segment D₂ was supplied by an additional artery. In 3 lobes (Specimens M6, M9, M16), the additional artery was distal, and in 2 (Specimens M4, M5), proximal to the main segmental artery. In 2 lobes (Specimens M7, M11), the additional artery arose at the same level as the main artery, but lateral to it, and supplied a small lateral part of the segment.

Segment D₃ - In 17 out of 18 lobes the origin of artery D₃ was slightly distal to the origin of the corresponding bronchus. In one lobe (Specimen E52) its origin was opposite the root of the bronchus. In 16 out of 18 lobes the artery turned to the caudal aspect of the rami of bronchus D₃. In one lobe (Specimen M8) the main branches were lateral, and in the other (Specimen E52) at first lateral and then some branches were caudal and others cephalic to the segmental bronchus.

Additional Arteries - In 8 lobes this segment was supplied by one additional artery. In 7 of these (Specimens M2, M4, M7, M9, M13, M14, E52) the origin of the additional artery was proximal to that of the main artery, and in one (Specimen E49) at the same level and lateral to it, supplying a small lateral part of the segment.

In one lobe (Specimen M16), 2 additional arteries were found, one originating from the lobar artery proximal to the principal artery, and another originating from the artery supplying the area of the accessory bronchus m₁.

Segment V₁ - The origin of artery V₁ was found to be

opposite the root of bronchus V_1 in all except 3 lobes in which it was a little proximal to it. The artery ramifies along the lateral aspect of the branches of the bronchus. This and the corresponding artery on the right side are the largest segmental ^{two} arteries in the / lungs.

Additional Arteries - Only in one lobe (Specimen M2) was an additional artery found, and it arose distal to the main segmental artery.

Segment V_2 - In all lobes the origin of artery V_2 was opposite the root of the corresponding bronchus, and it ramified on the lateral aspect of the bronchial rami.

Additional Arteries - An additional artery was found in 2 lobes. In one (Specimen M16) this artery arose proximal to the main, and in the other (Specimen E50) the additional artery was a branch of an artery supplying the area of an accessory bronchus.

Segment T - The T-segment was supplied by the continuation of the main artery.

The number of arteries supplying each segment, in 18 lobes examined, is given in Table 23.

SPECIMEN M.1

SPECIMEN M.4

Table 23

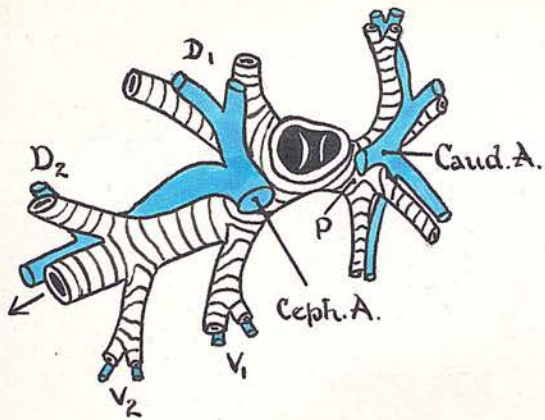
NUMBER OF ARTERIES SUPPLYING EACH SEGMENT
OF THE LEFT DIAPHRAGMATIC LOBE

Segments and the No. of Arteries					Details of Specimens	No. of Lobes
D ₁	D ₂	D ₃	V ₁	V ₂		
1	1	1	1	1	M1, M3, M8, M10, E56	5
1	1	2	2	1	M2	1
1	1	2	1	1	E49	1
2	2	2	1	1	M4	1
1	2	1	1	1	M5, M6, M11	3
1	2	2	1	1	M7, M9	2
1	1	2	1	1	M13, M14	2
2	2	3	1	2	M16	1
1	1	1	1	2	E50	1
2	1	2	1	1	E52	1
					Total	18

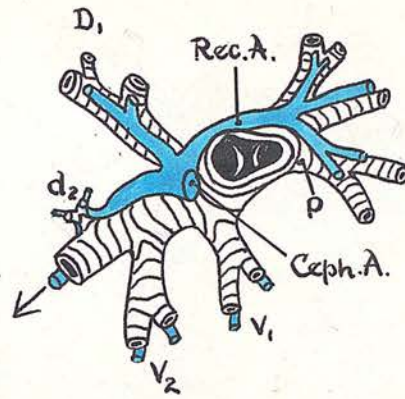
PLATE I

ARTERIES - RIGHT APICAL LOBE - MEDIAL VIEWS

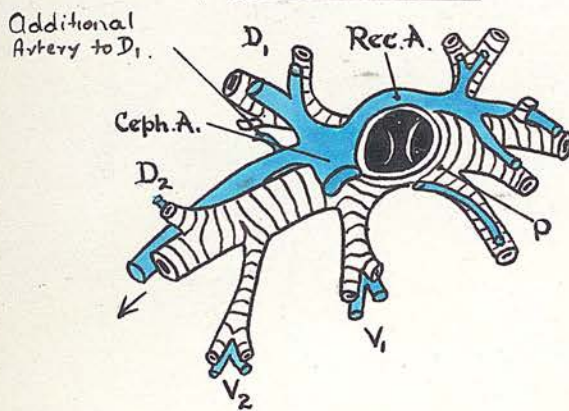
SPECIMEN M.1.



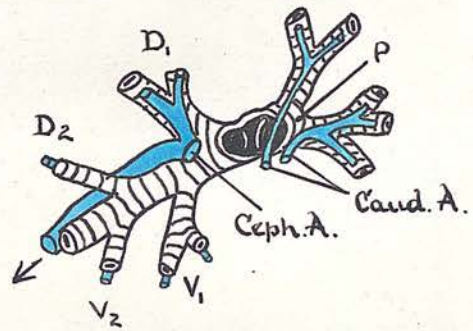
SPECIMEN M.4



SPECIMEN M.6.



SPECIMEN M.16



SPECIMEN M.9.

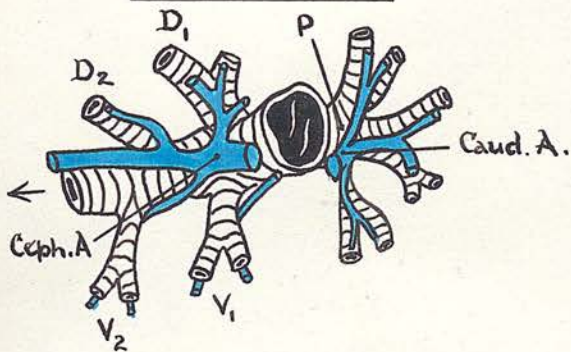
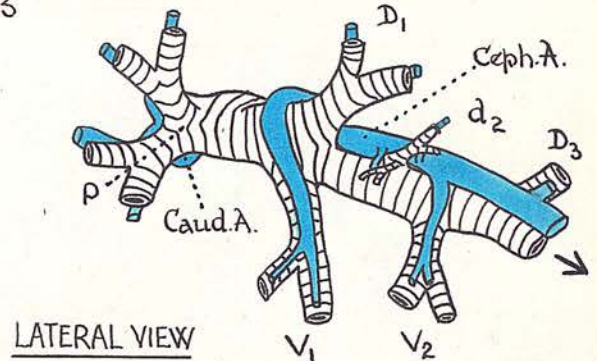
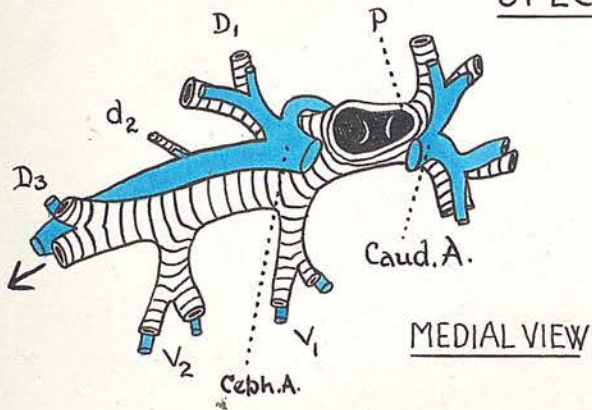


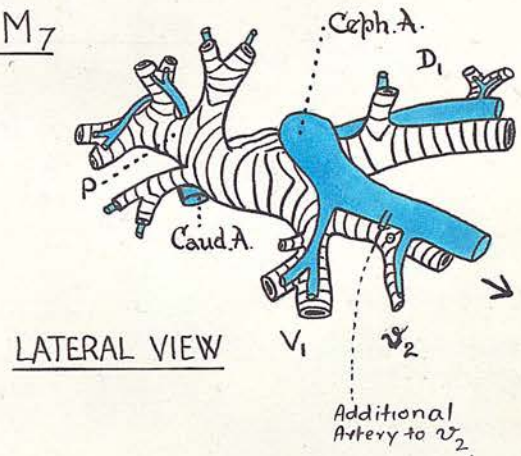
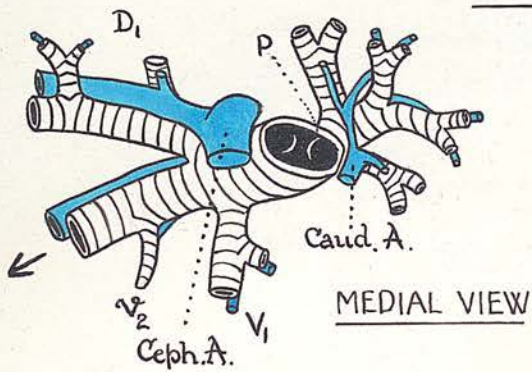
PLATE I

ARTERIES - RIGHT APICAL LOBE - MEDIAL VIEWS

SPECIMEN M₃



SPECIMEN M₇



SPECIMEN M₁₃

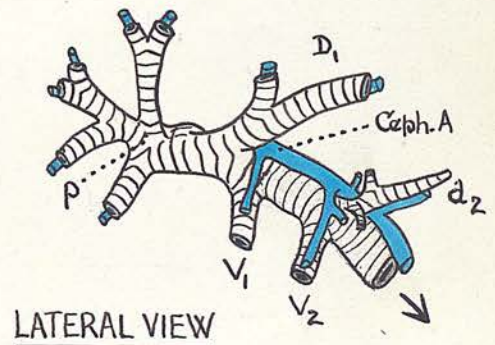
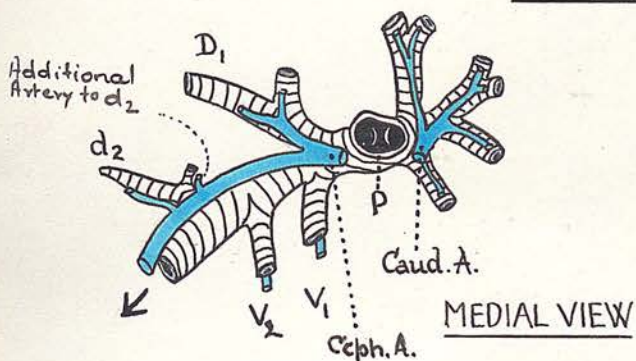
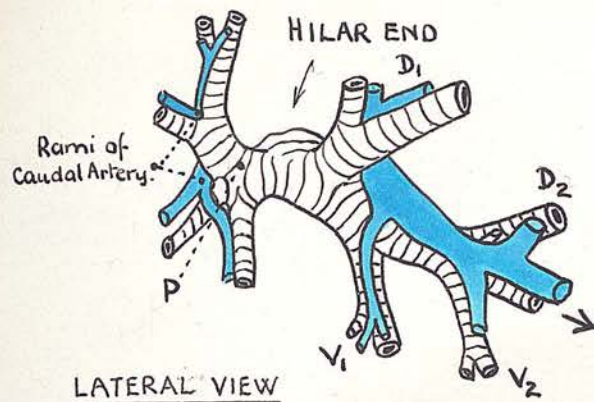


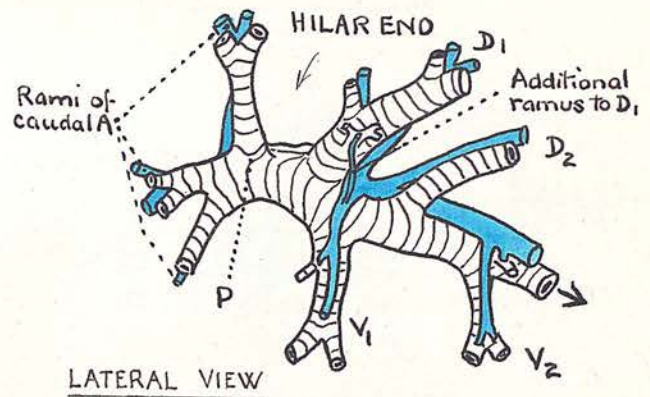
PLATE II

ARTERIES - RIGHT APICAL LOBE

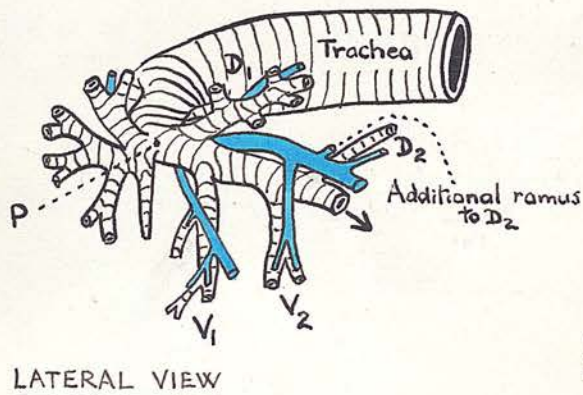
SPECIMEN M.1.



SPECIMEN M.2.



SPECIMEN E.52



SPECIMEN E.52

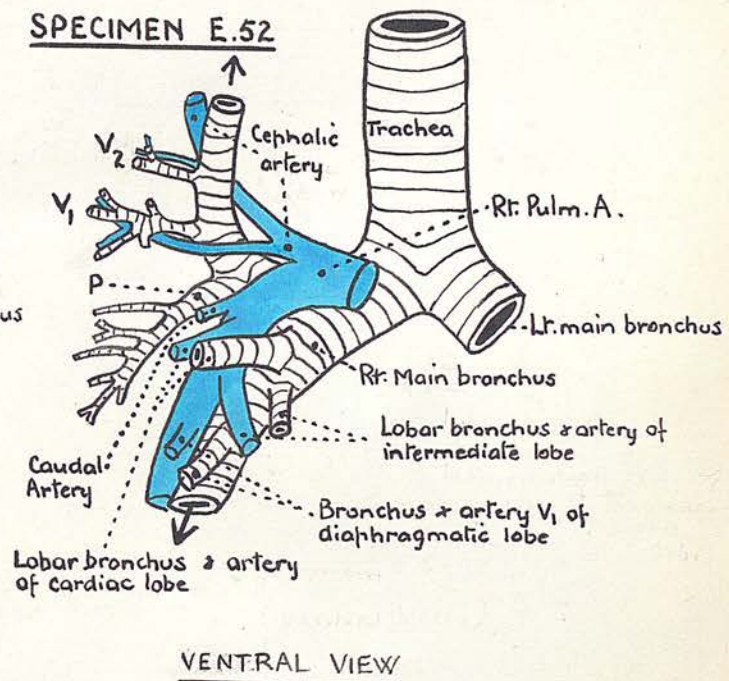
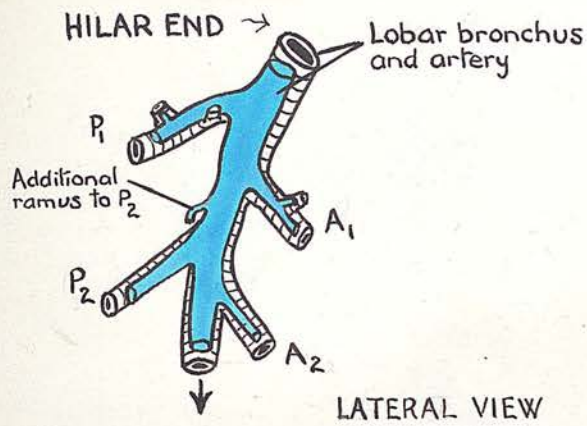


PLATE III

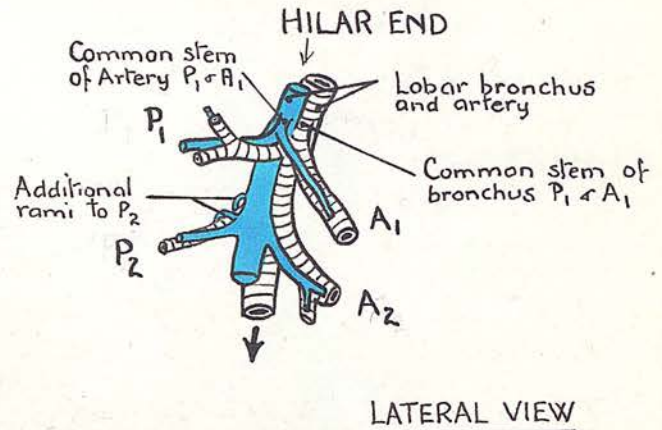
ARTERIES — RIGHT APICAL LOBE

RIGHT CARDIAC LOBE

SPECIMEN M.2

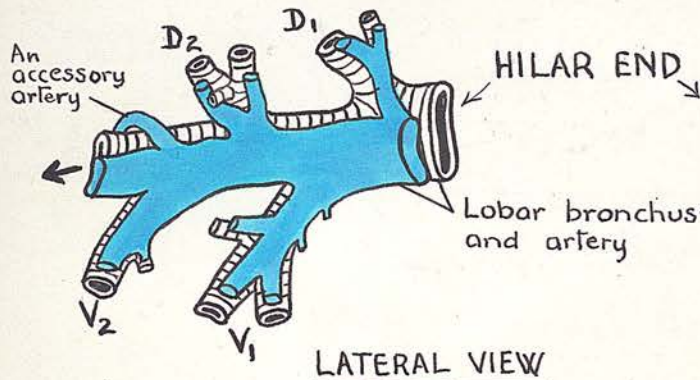


SPECIMEN M.14



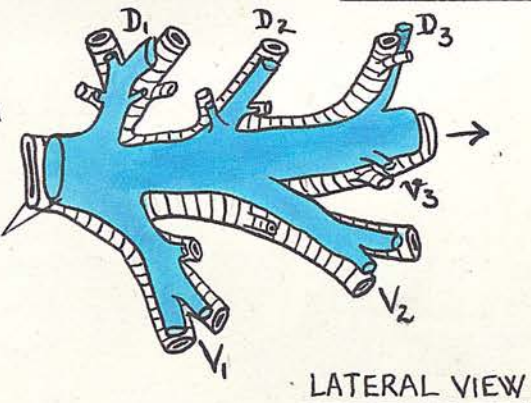
RIGHT DIAPHRAGMATIC LOBE

SPECIMEN M.3



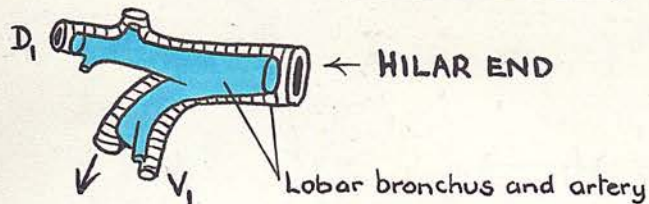
LEFT DIAPHRAGMATIC LOBE

SPECIMEN M.3.



INTERMEDIATE LOBE

SPECIMEN M5

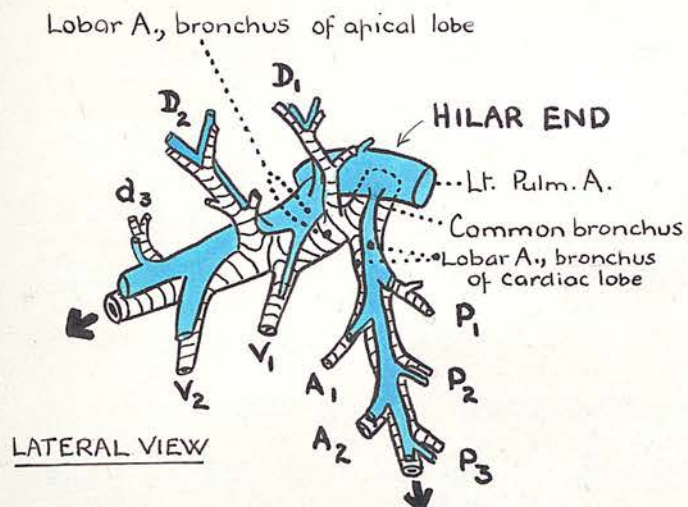


LATERAL (RIGHT) VIEW

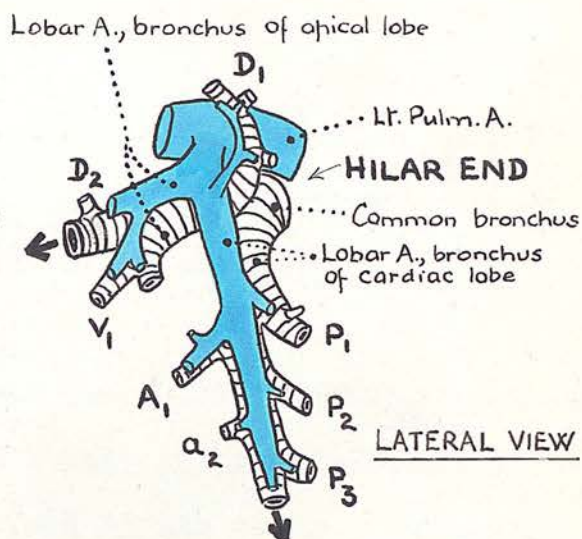
PLATE IV

ARTERIES

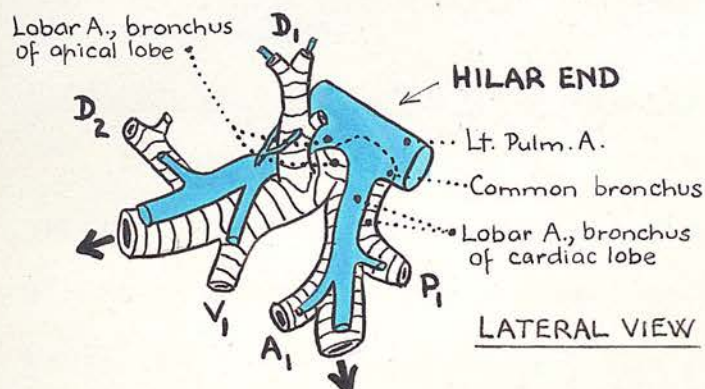
SPECIMEN E.49



SPECIMEN M.8



SPECIMEN M.6



SPECIMEN M.10

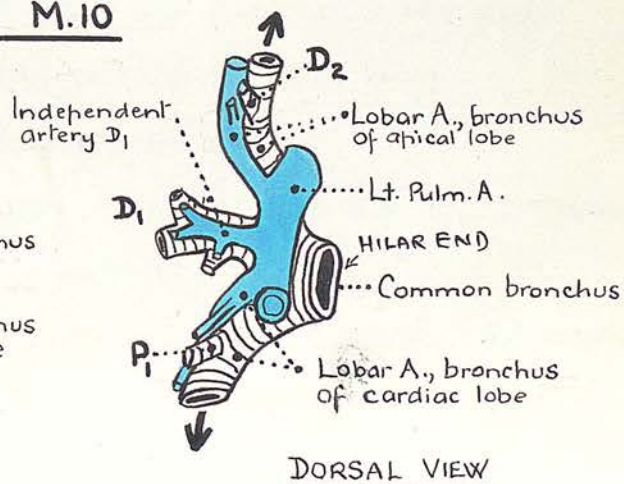
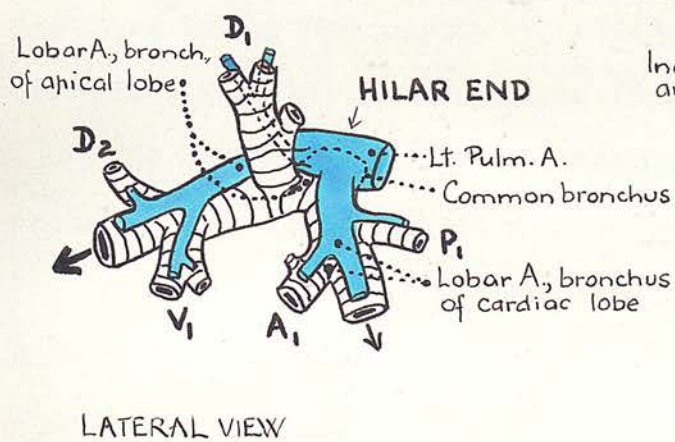


PLATE V.

ARTERIES - LEFT APICAL AND CARDIAC LOBES

PULMONARY VEINS

Modes of Termination of the Pulmonary Veins in the Left Atrium

Two additional dissected specimens (M12, M15) were included for the study of the modes of termination of the pulmonary veins into the left atrium, making a total of 20 specimens (16 dissections and 4 casts).

The study of the arrangement of the orifices of the pulmonary veins in the left atrium is possible only in the dissected specimens, as no orifices can be recognised in the casts. Therefore, the findings in the dissected and in the corrosion specimens are given separately.

Findings in the Dissected Specimens

The pulmonary orifices, all unguarded by valves, present variable appearances. Some of them were well marked with distinct margins. Others were faintly demarcated from the cavity of the atrium, so that the walls of veins were imperceptibly continuous with those of the atrium. In many specimens the muscular tissue of the atrial wall was traceable for some distance along the pulmonary veins, making it even more difficult to mark the point of entrance of veins.

The different modes of entrance of veins and the appearances presented by their orifices are illustrated in ^{Plates} ~~Figs.~~ VI & VII.

One vein was found to issue from each of the seven lobes of each pair of lungs. In all specimens the vein of the intermediate lobe drained into the vein of the right diaphragmatic lobe. The resulting 6 veins, 3 from each lung, drained into the left atrium. Their exact mode of termination being variable, 4 to 6 orifices were recognisable in the left atrium. The following four types of arrangement were found:-

1. In 6 lungs (Specimens M1, M2, M12, M14, M15, M11), each of the 6 veins opened independently, there being 6 orifices and 6 pulmonary veins (Plate VI, Specimen M1).

2. In 5 lungs (Specimens M3, M6, M7, M8, M9), each lobar vein opened independently on the right side, but on the left side the veins of the apical and the cardiac lobes joined and opened by a common orifice. In 3 of these (Specimens M3, M6, M7), the common stem formed was so short that the 2 veins appeared from outside to open independently, but when examined from the cavity of the atrium they were found to possess a common orifice (Plate VI, Specimen M3). In the other 2 specimens (M8, M9) the common stem formed was of a considerable length (Plate VI, Specimen M9).

Thus the number of orifices in each of these 5 specimens was reduced to 5 in each atrium.

3. In 4 lungs (Specimens M5, M10, M13, M16) the veins from the left apical and the left cardiac lobes joined to open, as in the preceding type. In addition, the corresponding veins of the right side also shared a common opening. The veins of the diaphragmatic lobes opened independently. The number of orifices in this type of arrangement was reduced to 4 in each atrium.

In 2 of these 4 specimens (M5, M13), the common stem on the right side was of considerable length (Plate VI, Specimen M13), whereas in the other 2 specimens (M10, M16) it was very short (Plate VI, Specimen M10).

4. In the remaining single lung also there were 4 orifices but the arrangement was different. The apical and the cardiac lobar veins of the right side had a common opening, as described under Type 3. On the left side the veins from the cardiac and the diaphragmatic lobes formed a short common stem and shared a

common opening (Plate VI, Specimen M4).

Findings in Four Corrosion Preparations

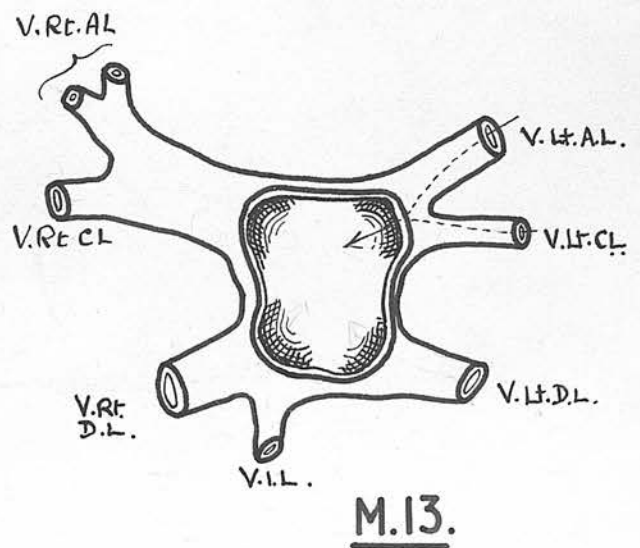
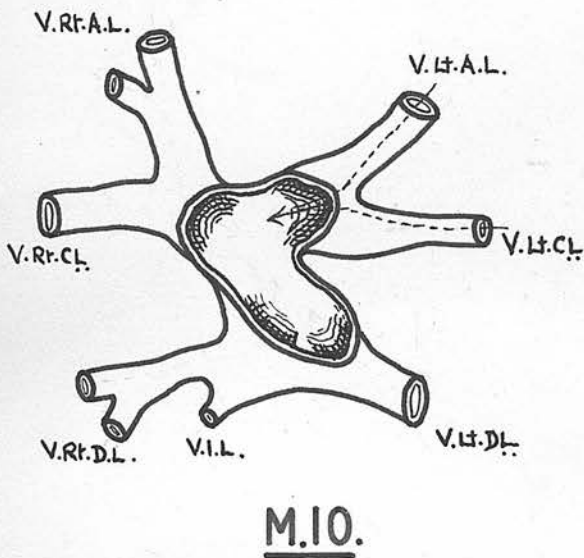
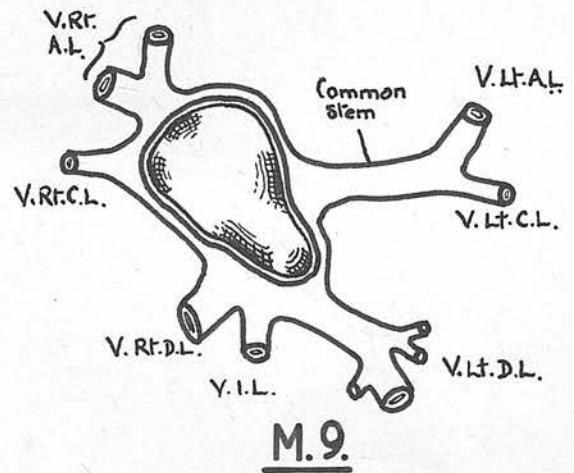
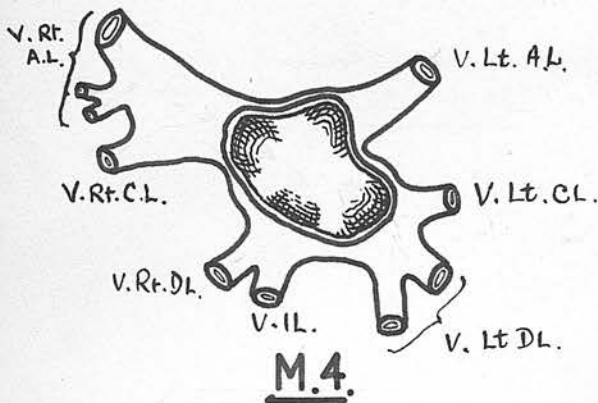
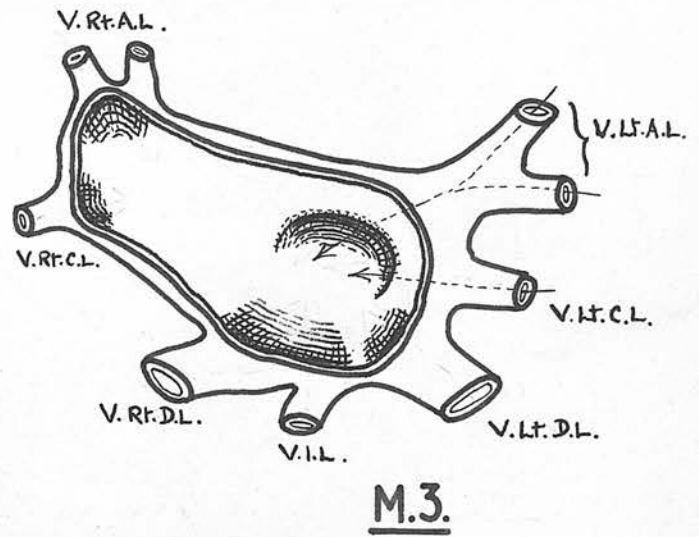
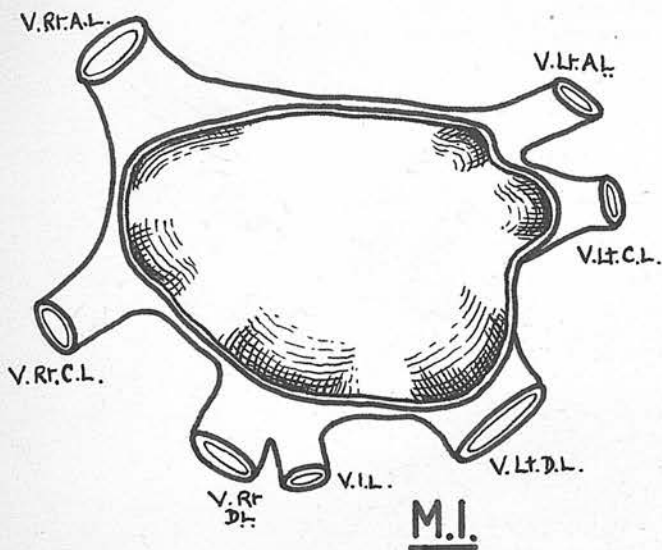
The modes of the termination of the veins, in the four corrosion preparations, are diagrammatically represented in Plate VII. The cast of the cavity of the left atrium did not permit the use of the camera lucida for making drawings of the veins, as their points of entrance were concealed by the cast of the atrium, when viewed from the ventral aspect.

It will be noticed that, in all the four casts, as in the dissected specimens, the veins of the right apical and the cardiac lobes open close together, and that the stems of the veins of the apical lobes (shaded parts) are short. The veins from the right diaphragmatic lobes open independently after receiving the veins from the intermediate lobes.

On the left side, the lobar veins are seen to enter the left atrium separately in each specimen. In one specimen (E56) the apical lobe vein is seen to enter the dorsal wall of the atrium almost at its centre, and the left cardiac lobe vein opens so close to the vein of the diaphragmatic lobe that they appear to have shared a common opening.

From the study of the dissected as well as corrosion specimens, it is concluded that each of the ^{seven} // lobes is drained (Plate VII, by a single vein, the only exception being 2 intermediate lobes / (Specimens E50, E52) each of which was drained by 2 veins. But there are 6 main veins, 3 from each lung (the vein of the intermediate lobe being constantly a tributary of the vein of the right diaphragmatic lobe), which open into the left atrium by a number of orifices which varies from 4 to 6.

PLATE VI



Modes of Termination of Pulmonary Veins in left Atrium of Dog - Ventral View

V. Rt. A.L. - Vein right apical lobe

V. Rt. C.L. - Vein right cardiac lobe

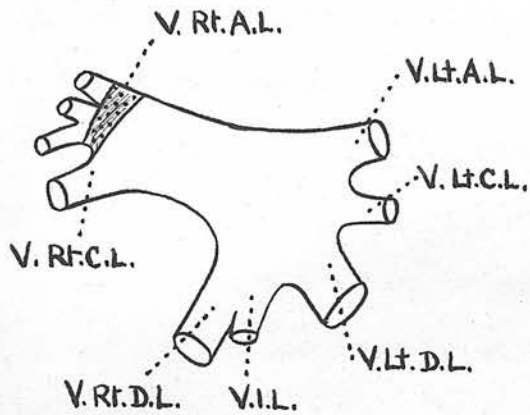
V. Rt. D.L. - Vein right diaphragmatic lobe

V. I.L. - Vein intermediate lobe

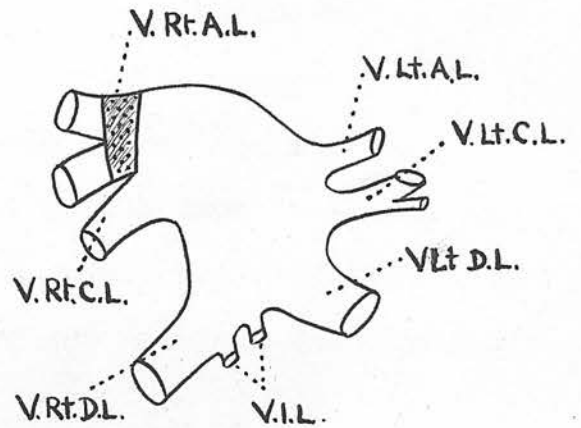
V. Lt. A.L. - Vein left apical lobe

V. Lt. C.L. - Vein left cardiac lobe

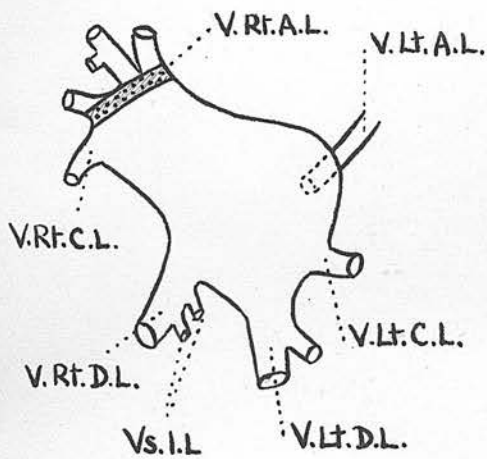
V. Lt. D.L. - Vein left diaphragmatic lobe.



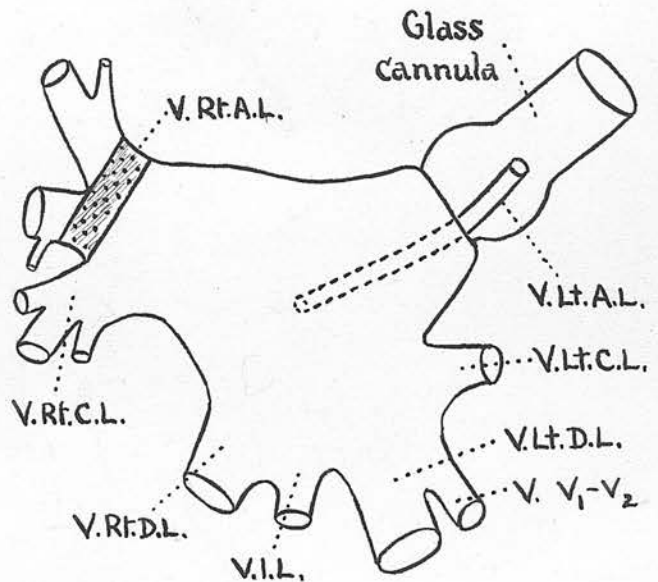
SPECIMEN E.49



SPECIMEN E.50



SPECIMEN E.52



SPECIMEN E.56

PLATE VII

Modes of Termination of Pulmonary Veins in 4 Casts.

- Diagrammatic.

GENERAL REMARKS ON THE VEINS OF ALL LOBES

Although the venous pattern does not exhibit so close a resemblance to the bronchial pattern as does the arterial, yet there is a certain amount of similarity between them.

Each lobar vein may be considered as the "axial" vein which runs through the lobe parallel to the lobar bronchus and the artery. It receives tributaries which are roughly arranged in two series in conformity with the arterial and the bronchial arrangements.

In the majority of the lobes the lobar stem bronchus and the accompanying lobar artery were seen to be traceable almost up to the extreme terminal end of the lobe. The commencement of the lobar vein, on the other hand, takes place, in the majority of lobes, at a point much more proximal than that of the termination of the lobar artery and the bronchus.

Unlike the arteries, the veins do not accompany the bronchi. They tend to keep as far away from the bronchi as possible. A vein only comes into relationship with a bronchus when it has to cross it. These points, however, do not apply to the lobar vein itself which runs close to the lobar stem bronchus but not so closely as does the lobar artery.

The arteries generally accompany the bronchi on their peripheral aspects. (In the case of the intermediate lobe, as stated before, this corresponds to the diaphragmatic aspect.) The veins lie on the side of the bronchi opposite to that on which the arteries lie.

The broncho-vascular tree of both lungs may thus be visualised roughly to be arranged in 3 planes, an external arterial, a middle bronchial and an internal venous. Some

exceptions in the case of arteries have already been described. Those of the veins will be mentioned later. ~~opposite series~~

Generally, each space between the two serial bronchi contains a single vein which runs parallel to them, and drains the territories between which it lies. It opens independently into the lobar vein. There were examples, however, of ^{two} / veins of variable sizes instead of one, draining a space. Not infrequently ^{two} / veins from adjacent spaces join to form a common stem before opening into the lobar vein. There were also multiple examples where a vein was found to "expand" its area of drainage by encroaching upon distant territories.

A certain territory is thus generally drained by the veins between which it lies.

Sometimes in the case of a larger territory there may be a prominent vein which drains only a part of it, and opens either independently into the lobar vein or into one of the adjoining interbronchial veins. Such a vein will be indicated by the symbol which designates the segment it drains. An example may be seen in Specimen M5 in Fig. 42 in which vein V_1 drains a large portion of segment V_1 only.

When a certain bronchus in a series is underdeveloped and the area supplied by it small, a single large vein usually drains this small area and the two adjoining areas between which it lies. Such an example may be seen in Specimen M14 illustrated in Fig 45 in which vein A_1 -T drains the underdeveloped area of bronchus a_2 and the two adjoining areas of bronchi A_1 and A_3 .

There were a few examples in which even territories supplied by 4 serial bronchi were drained by a single vein.

Few instances were encountered where a vein drained an area supplied by a bronchus belonging to the opposite series by means of tributaries of any considerable size.

From the foregoing general observations it will have been appreciated that the veins are liable to show a greater degree of variations than do the arteries and the bronchi. The exact pattern of veins in a certain lobe is further modified by its bronchial pattern.

The extensive variations of the veins have already been pointed out. The veins are even more variable. They all drain into the part of the lobar vein which traverses the 2-segment and may, therefore, be called the terminal segmental vein.

It may be pointed out here that in addition to the veins described below, there were a number of small and irregular veins which, for the sake of simplicity, have been ignored.

It is felt that the method of describing the segmental veins is complicated but it appears justified in view of their complex arrangement.

VEINS OF THE RIGHT LUNG

(Fig. 40, Plate IV)

The arrangement of veins in the right lung is somewhat that of the arteries in the respect. The arteries, in the majority of lobes, were seen to consist of a caudal and a cephalic artery, the former supplying the 2-segment and the latter the whole of the remaining lobe. The veins too, consist of the almost corresponding veins, one draining the area supplied by the caudal artery and the other the remaining lobe. These veins have therefore been termed the "caudal" and the "cephalic" veins respectively, the latter forming the main lobar vein.

VEINS OF THE INDIVIDUAL LOBES

The description of the veins is based on the same 18 pairs of lungs which were used for the arteries. As in the case of the arteries, they will be described on segmental basis.

The account of the veins of the T-segment of all the lobes can be disposed off here collectively. The composite nature of the T-segment and the extensive variations of its bronchi have already been pointed out. The veins are even more variable. They all drain into the part of the lobar vein which traverses the T-segment and may, therefore, be called the Terminal Segmental vein.

It may be pointed out here that in addition to the veins described below, there were a number of small and irregular veins which, for the sake of simplicity, have been ignored.

It is felt that the method of denoting the segmental veins is complicated but it appears justified in view of their complex arrangement.

VEINS OF THE RIGHT APICAL LOBE

(Fig. 40, Table 24)

The arrangement of veins in the right apical lobe resembles that of the arteries in one respect. The arteries, in the majority of lobes, were seen to consist of a caudal and a cephalic artery, the former supplying the P-segment and the latter the whole of the remaining lobe. The veins, too, consist of two almost corresponding veins, one draining the area supplied by the caudal artery and the other the remaining lobe. These veins have therefore been termed the "caudal" and the "cephalic" veins respectively, the latter forming the main lobar vein.

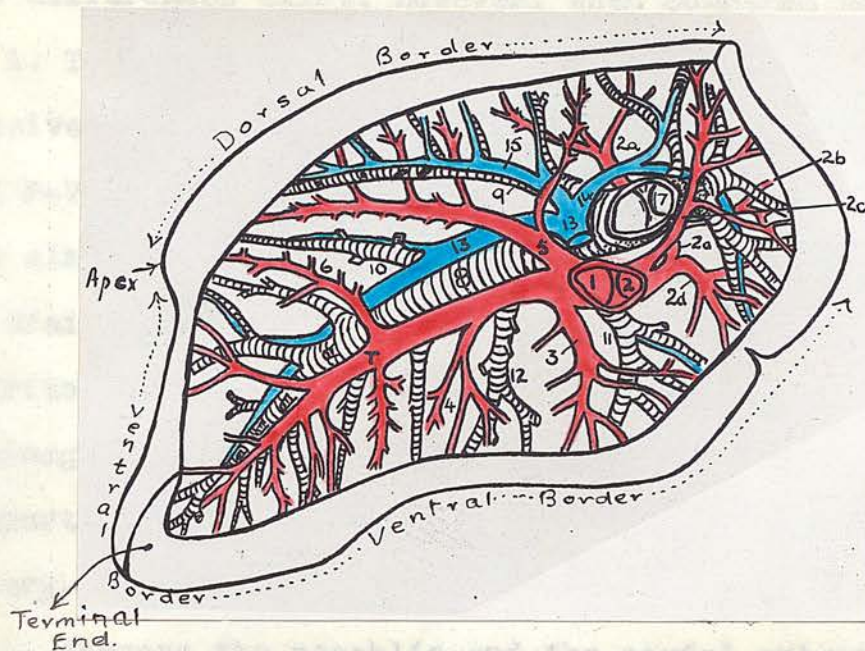


Fig. 40 . Venous Drainage of Right Apical Lobe of Dog - Medial View (Specimen M14)
Veins, red; Arteries, blue; Bronchi, cross-hatched.

- | | |
|--|--|
| 1. Cephalic Vein | 7. Bronchus P |
| 2. Caudal Vein | 8. Lobar stem bronchus |
| 2a. Vein P-D ₁ | 9. Bronchus D ₁ |
| 2b. Lateral Vein | 10. Bronchus D ₂ |
| 2c. Medial Vein | 11. Bronchus V ₁ |
| 2d. Vein P-V ₁ | 12. Bronchus V ₂ |
| 3. Vein V ₁ -V ₂ | 13. Cephalic Artery |
| 4. Vein V ₂ -T | 14. Recurrent Artery |
| 5. Vein D ₁ -D ₂ | 15. Artery D ₁ |
| 6. Vein D ₁ -T | T Terminal Vein - continuation of lobar vein |

In this specimen caudal artery is absent and is represented by the recurrent artery.

Two differences exist, however, when compared to the arteries:-

1. The caudal vein, in addition to draining the P-segment, receives tributaries draining the interbronchial spaces, P-D₁ and P-V₁, which not only receive tributaries from the P-segment but also from the adjoining segments, D₁ and V₁. The territory of drainage of the caudal vein, therefore, is larger than the territory of supply of the corresponding artery. The area of drainage of the cephalic vein (i.e., the remaining lobe) is proportionately smaller than the area of supply of the cephalic artery.

2. Whereas the cephalic and the caudal arteries were found to originate independently from the pulmonary artery in the majority of specimens, the two veins unite to form a common vein, the union taking place at the hilum or a little outside it, ventro-cephalic to the lobar bronchus.

THE CAUDAL VEIN

As stated already, it drains the whole of P-segment and the adjoining parts of Segments D₁ and V₁.

Tributaries

All tributaries of the caudal vein converge and unite at the hilum ventral or ventro-cephalic to the lobar bronchus. Four main tributaries may be described according to ^{the} areas drained.

1. Small tributaries from the caudal part of segment D₁ and the dorsal part of segment P unite in the interbronchial space P-D₁ and form a vein, to be referred to subsequently as "vein P-D₁", which runs ventrally to pass lateral to the angle between the segmental bronchus P and the lobar stem bronchus. It then passes medially ventral to ^{the} lobar bronchus to emerge

at the hilum. This tributary was found to be present in all specimens examined.

2. A vein, designated P-V₁, drains the adjoining parts of segments P and V₁. It is directed dorsally and joins other tributaries of the caudal vein in the ventral part of the hilum. It was present in all specimens.
3. A small vein drains the lateral part of the P-segment. It has been named the "lateral" vein of the P-segment. In the majority of lobes it drained into vein P-D₁. In others it passed through the angle between bronchus P and the lobar stem bronchus, along with vein P-D₁, to join other tributaries at the hilum. It was present in all except 3 specimens (M7, M8, M11) in which the "medial vein" (described below) was large to compensate for its absence.
4. A fourth vein drains the part of segment P which lies subjacent to the fissural surface for the diaphragmatic lobe. The vein passes ventro-caudal to the lobar bronchus and the caudal artery, to join the other tributaries of the caudal vein. In one lobe (Specimen M2) it passed lateral to the angle between bronchus P and the lobar stem bronchus. This vein has been called the "medial vein" of the P-segment and was present in all the lobes examined.

The exact mode of union, at the hilum, of the four veins described above, was very variable.

Variations

In one lobe (Specimen M7), in which segments P and V₁ were separated by a deep rudimentary fissure, vein P-V₁ received no tributaries from segment V₁. It ran under the caudal face of the fissure. Strictly speaking, this vein in

this specimen should not be called vein P-V₁ as it drained the P-segment only.

In 1 lobe (Specimen M10) vein P-V₁ was "split" into two tributaries by the presence of a rudimentary fissure between segments P and V₁, into a cephalic tributary draining segment V₁ and a caudal tributary draining segment P. The former joined vein P-D₁, and the latter joined the common stem formed by the medial and the lateral veins. Each of the two veins thus formed opened independently into the cephalic vein.

In 2 other lobes (Specimens M2, M16), due to the presence of a rudimentary fissure between segments P and V₁, vein P-V₁ was "split" into 2 tributaries, each draining the area subjacent to the two surfaces of the fissure, but the two tributaries joined to form a single vein before entering the caudal vein.

In 1 lobe (Specimen M5) the medial vein did not drain into the caudal vein, and instead opened independently into the lobar vein outside the hilum.

In 1 lobe (Specimen E50), the caudal vein received an independent vein from segment V₁ (vein V₁).

In 2 lobes (Specimens E50, E56), the caudal vein received a vein draining segment P₁ of the cardiac lobe (vein P₁), which reached it by crossing the pulmonary artery under the pleura, at the depth of the major and the minor fissures of the lung.

THE CEPHALIC VEIN

The cephalic vein represents the main lobar vein. It runs parallel to the lobar stem bronchus in the concavity of its cardiac curve and ventro-medial to it. ^{or a little outside} At the hilum it receives the caudal vein. Its tributaries may be described under two headings, the dorsal and the ventral.

Dorsal Tributaries

The arrangement of the dorsal tributaries of the cephalic vein was found to vary according to whether the second dorsal bronchus supplied a normal-sized segment or a segmentellette.

Arrangement when Segment D₂ was of a normal size

When segment D₂ was of a normal size, each of the inter-bronchial spaces D₁-D₂ and D₂-T were drained by independent veins, D₁-D₂ and D₂-T respectively (Fig. 40). This arrangement existed in 8 lobes (Specimens M1, M2, M5, M8, M9, M14, M16, E52).

Vein D₁-D₂, in all the 8 lobes, commenced in the distal part of the corresponding space near the dorsal border of the lobe, and traversed it in a caudo-ventral direction. In 7 out of these 8 lobes, after crossing the lobar bronchus on its medial aspect, it opened into the cephalic vein independently. In the 8th lobe (Specimen M9), it joined vein D₂-T opposite the lobar stem bronchus to form a common vein before opening into the cephalic vein.

During its course vein D₁-D₂ received larger tributaries from segment D₁ and smaller ones from segment D₂.

Vein D₂-T, in 6 out of 8 lobes (Specimens M2, M5, M8, M9, M14, M16), commenced in the distal part of the corresponding space. It crossed medial to the lobar stem bronchus to terminate in the cephalic vein. In one of these lobes (Specimen M9), as mentioned above, it joined vein D₁-D₂ to open into the cephalic vein by a common stem.

In 1 lobe (Specimen M1), its commencement was about the middle of the space, the distal part being drained by tributaries of the veins of the T-segment; otherwise its course was the

same as in the preceding 6 lobes.

In the 8th lobe (Specimen E52) the vein was rudimentary, and it drained only the proximal part of the space; more than distal half of the space was drained by tributaries, some of which joined vein D_1-D_2 and the others the veins of the T-segment. Arrangement when Segment D_2 was underdeveloped (a segmentellette).

Segment D_2 was underdeveloped in 10 lobes:-

(a) In 9 lobes out of these 10, (Specimens M3, M4, M6, M7, M10, M11, M13, E50, E56), the arrangement was as follows:-

The two veins, D_1-D_2 and D_2-T , described above, were replaced by a single vein designated vein D_1-d_2-T . It commenced near the distal part of the space between bronchi D_1 and D_3 (the latter bronchus belongs to T-segment) and passed in a ventro-caudal direction either medial to bronchus d_2 or opposite either of the spaces, D_1-d_2 and d_2-T . Its chief tributaries came from segment D_1 .

In 8 lobes out of these 9, the vein passed medial to the lobar bronchus to enter the cephalic vein.

In the 9th lobe (Specimen E50), it passed lateral to the lobar bronchus to join vein V_1-V_2 (described later), both of which then drained into the cephalic vein by a common stem.

In the same lobe, in addition to vein D_1-d_2-T , two additional veins drained space d_2-T . One of them crossed the lobar bronchus on its lateral aspect and drained into vein V_2-T . The other crossed it on its medial aspect to open independently into the cephalic vein. These two veins have been designated as veins d_2-T (lateral) and d_2-T (medial) respectively according to their positions in relation to the lobar bronchus.

In one of these 9 lobes (Specimen M10), segment D_1 was drained by an additional vein which commenced between the first two dorsal "subsegmental" rami of bronchus D_1 . It opened independently into the cephalic vein, draining only a small caudal part of segment D_1 . As it drained no other segment, this vein has been called vein D_1 .

(b) In the remaining single lobe (Specimen E49), despite the second dorsal segment being a segmentellette, an independent vein drained each of the two spaces, D_1-d_2 and d_2-T . The commencement of both these veins was in the space D_1-T . The course of the former was the same as that of vein D_1-D_2 , and of the latter same as that of vein D_2-T , described above. These veins have been named as veins D_1-d_2 and d_2-T respectively.

Other members of the ventral tributaries were veins V_1 and V_2 described below.

Vein V_1 drained segment V_1 alone in 12 lobes. The arrangement of

(a) In 5 lobes (Specimens M1, M2, M3, M4, M5, M6, M8, M9, M10, M11, M13, M14, E49, E50, E52, E56), vein V_1 drained

The ventral tributaries comprise veins draining spaces V_1-V_2 and V_2-T (veins " V_1-V_2 " and " V_2-T " respectively), and separate veins draining parts of each of the two segments V_1 and V_2 (veins " V_1 " and " V_2 " respectively). The findings were as follows:-

(a) In 16 lobes (Specimens M1, M2, M3, M4, M5, M6, M8, M9, M10, M11, M13, M14, E49, E50, E52, E56), each of the spaces V_1-V_2 and V_2-T were drained by corresponding veins V_1-V_2 and V_2-T .

Vein V_1-V_2 , in one of these lobes (Specimen E50), as already mentioned, received vein D_1-d_2-T to form a common stem before joining the cephalic vein. In two other lobes out of these (Specimens M8, M11), it received vein V_1 (vide infra).

Vein V_1-V_2-T .

In one of these lobes (Specimen E50), vein V_2 -T received vein d_2 -T (lateral) before opening into the cephalic vein.

Both veins V_1 - V_2 and V_2 -T, in these 16 lobes, opened independently into the cephalic vein after crossing medial to the lobar stem bronchus.

(b) In 1 lobe (Specimen M7) segment V_2 was a segmentellette, but each of the spaces V_1 - v_2 and v_2 -T was drained by independent veins, V_1 - v_2 and v_2 -T respectively, both draining into the cephalic vein independently.

(c) In the remaining lobe (Specimen M16), segment V_2 was a segmentellette and a single vein V_1 - v_2 -T drained both spaces V_1 - v_2 and v_2 -T. It received vein V_1 from segment V_1 before joining the cephalic vein (vide infra).

Other members of the ventral tributaries were veins V_1 and V_2 described below.

Vein V_1 drained segment V_1 alone in 12 lobes. The arrangements/ were:-

(a) In 5 lobes (Specimens M1, M3, M4, M5, M13), vein V_1 drained the middle part of segment V_1 . It passed medial to the branches of the segmental bronchus to join the cephalic vein. In 3 out of these 5 lobes (Specimens M1, M4, M13), its opening was close to the opening of vein V_1 - V_2 .

(b) In 3 lobes (Specimens M2, M7, E50), it drained the caudal part of segment V_1 . In 2 of these (Specimens M2, M7), it joined the cephalic vein, but in one lobe (Specimen E50) it drained into the caudal vein.

(c) In 3 other lobes (Specimens M8, M11, M16), it drained the middle part of segment V_1 , but in two of these (Specimens M8, M11) it joined vein V_1 - V_2 , and in the third (Specimen M16) it joined vein V_1 - v_2 -T.

Table 24

VEINS OF THE RIGHT APICAL LOBE OF DOG

(in 18 specimens)

(+ sign signifies the presence of the vein in the specimen)

CAUDAL VEIN				CEPHALIC VEIN														No. of Lobes	Details of Specimens
				Dorsal Tributaries								Ventral Tributaries							
Vein P-D ₁	"	"	"	D ₁ -D ₂	D ₁ -d ₂	D ₁ -T	D ₁ -d ₂ -T	D ₁	D ₂ -T	d ₂ -T (medial)	d ₂ -T (lateral)	V ₁ -V ₂	V ₁ -v ₂	V ₁ -v ₂ -T	V ₁	V ₂ -T	v ₂ -T	V ₂	
+	+	+	+	+					+			+		+	+				
+	+	+	+	+					+			+		+	+			+	
+	+	+	+				+					+		+	+			+	
+	+	+	+				+					+		+	+				
+	+	+	+				+					+		+					
+		+	+		+								+		+		+		
+		+	+	+				+				+		+	+				
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+	+	+	+		+				+			+			+				
+	+	+	+				+		+	+		+			+	+			
18	15	18	18	8	1	1	8	1	8	2	1	16	1	1	12	16	1	4	
Frequency of each vein																			

VEINS OF THE RIGHT CARDIAC LOBE

(Fig 41, Table 25)

The Lobar Vein

The lobar vein commences at or near the terminal end of the lobe. It proceeds towards the hilum, running parallel and cephalic to the lobar stem bronchus and the m-branches, subjacent to the cardiac surface. This arrangement was found in 14 out of 18 specimens.

In 2 lobes (Specimens M4, M5) out of the remaining 4, the vein, in the distal half of its course, ran caudal to the plane of the lobar stem bronchus. In its proximal half it crossed the lobar stem bronchus on its medial side to run the rest of its course as in the preceding 14 specimens. Its distal cephalic tributaries, in these 2 lobes, crossed medial to the lobar stem bronchus to open into the lobar vein.

In one lobe (Specimen M13) it commenced at the terminal end of the lobe as two tributaries, one running in the space between overdeveloped bronchus A₃ and the lobar stem bronchus, and the other running in the space between overdeveloped bronchus P₂ and the lobar stem bronchus. Both these veins were of equal size and it was not possible to determine which out of the two was the continuation of the main lobar vein.

In the remaining lobe (Specimen E52), in which the lobar stem bronchus bifurcated into two equal sized branches (Chart II Specimen E52), the vein commenced between the two branches of the stem bronchus and, after crossing medial to the cephalic branch at its root, the vein continued its normal course cephalic to the lobar stem bronchus.

The position of the vein at the hilum has already been noted

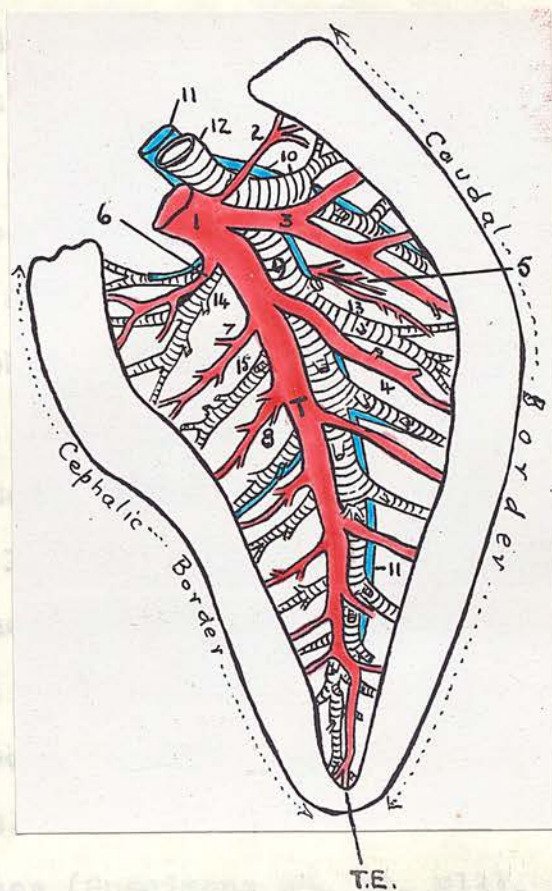


Fig. 4/1 . Venous Drainage of Right Cardiac Lobe of Dog - Medial View (Specimen M2) Veins, red; Arteries, blue; Bronchi, cross-hatched.

- | | |
|--|---|
| 1. Lobar Vein | 8. Vein A ₂ -T |
| 2. Vein P ₁ | 9. Lobar Stem Bronchus |
| 3. Vein P ₁ -P ₂ | 10. Bronchus P ₁ and Artery P ₁ |
| 4. Vein P ₂ -T | 11. Lobar Artery |
| 5. Lateral Vein | 12. Lobar Bronchus |
| 6. Vein A ₁ | 13. Bronchus P ₂ |
| 7. Vein A ₁ -A ₂ | 14. Bronchus A ₁ |
| | 15. Bronchus A ₂ |

T Terminal Vein - continuation of Lobar Vein.
T.E. Terminal End.

Caudal Tributaries

"Lateral" Vein (Figs. 37, 41)

In 17 out of 18 lobes, a vein was found to drain segments P_1 and P_2 , or segment P_1 alone, from their lateral aspect. In the 18th specimen, (M6) this vein was absent (Table 25). The following arrangements were found:-

(a) In 14 lobes (Specimens M1, M2, M3, M4, M7, M8, M10, M11, M14, M16, E49, E50, E52, E56), the vein received tributaries from both segments P_1 and P_2 ; larger tributaries came from segment P_1 . In 5 of these lobes (Specimens M3, M4, M11, M16, E52), it drained the whole of segment P_1 and the adjoining part of segment P_2 . In the remaining 9 lobes it drained ^{only} the adjoining parts of both segments, the remaining parts being drained by other veins.

(b) In 3 lobes (Specimens M5, M9, M13), the lateral vein received tributaries only from segment P_1 , in 2 of which (Specimens M5, M9) it drained the entire P segment, and in the third specimen (M13) only a part of it.

Course - In 16 lobes the vein, after collecting its tributaries, was found to proceed in interbronchial space P_1 - P_2 in a cephalic direction, crossing lateral to the lobar artery and bronchus. It then turned medially to pass dorsal to the root of bronchus A_1 to join the lobar vein. In the majority of these lobes small rudimentary veins from segment A_1 opened into it as it crossed bronchus A_1 .

In the remaining single specimen (M14), in which bronchi P_1 and A_1 were found to have a common stem of origin, the vein crossed the lobar artery and bronchus ventral to the common stem. It then joined vein A_1 - A_2 to form a common vein, which

passed medially ventral to bronchus A_1 (i.e., through inter-bronchial space A_1-A_2) to join the lobar vein.

The lateral vein drains either segments P_1 and P_2 , or P_1 alone and in the majority of specimens part of segment A_1 . It is, therefore, difficult to designate it the way the other veins have been. It has been, therefore, called the lateral vein because it lies lateral to the plane of the bronchi of the lobe and is thus distinguished from all other veins which lie in a plane medial to the plane of the bronchi.

Vein P_1-P_2

This vein drains segments P_1 and P_2 from the medial aspect.

In 9 lobes out of 18 (Specimens M3, M4, M5, M9, M11, M14, M16, E52, E56), this vein was absent as the drainage was taken up by the lateral vein.

It was present in the remaining 9 lobes (Specimens M1, M2, M6, M7, M8, M10, M13, E49, E50). In these it drained the adjoining parts of segments P_1 and P_2 from their medial aspects and opened into the lobar vein after crossing medial to the lobar bronchus. In one of these lobes (Specimen E50), it was rudimentary and drained only the proximal parts of segments P_1 and P_2 .

Thus it is seen that interbronchial space P_1-P_2 is drained by the lateral vein in 14 specimens and by vein P_1-P_2 in 9 specimens. In 8 specimens both were present (see Table 25, Specimens M1, M2, M7, M8, M10, M13, E49, E50).

Vein P_1

Vein P_1 , a small independent vein, present in 4 lobes

(Specimens M2, M14, E50, E56) drained the region subjacent to the "interfissural crest". The following arrangements were found:-

(a) In one lobe (Specimen M2), it joined the lobar vein by crossing medial to the lobar stem bronchus to open close to vein P₁-P₂.

(b) In 2 lobes (Specimens E50, E56), it crossed the pulmonary artery under pleura at the depth of the minor fissure to end in the caudal vein of the right apical lobe.

(c) In one lobe (Specimen M14), it crossed lateral to the lobar artery and bronchus of the cardiac lobe to enter the lobar vein.

Vein P₂-T

This vein drains segments P₂ and T. It runs in inter-bronchial space P₂-T (i.e., space P₂-P₃).

The following arrangements were found:-

(a) In 16 lobes (Specimens M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M14, M16, E49, E52, E56), it crossed medial to the lobar bronchus to join the lobar vein.

(b) In one lobe (Specimen E50), it crossed medial to bronchus p₃ to enter the T-segment in which it joined vein p₃-P₄.

(c) In one lobe (Specimen M13), in which the lobar vein was represented by 2 veins in the distal half of the lobe, this vein was absent.

Cephalic Tributaries

Vein A₁

Vein A₁ is a small vein which was present in all the lobes examined and drained the dorsal part of segment A₁.

The following arrangements were found:-

(a) In 8 lobes (Specimens M2, M4, M5, M6, M9, M13, M16, E49), it ran under the cardiac surface parallel to bronchus A₁ in a caudal direction to enter the lobar vein.

(b) In 4 lobes (Specimens M3, M7, M8, M10), the vein joined vein A₁-A₂ opposite the root of bronchus A₁ to open into the lobar vein by a common stem.

(c) In 5 lobes, in each of which it drained into the lateral vein, the following arrangements were found:-

(i) In 2 lobes (Specimens M1, M11), it joined the lateral vein as it crossed dorsal to bronchus A₁.

(ii) In 1 lobe (Specimen E50), it was a large vein, the tributaries lying lateral to the rami of bronchus A₁. It joined the lateral vein as it crossed the lobar artery.

(iii) In 1 lobe (Specimen E52), it was rudimentary and drained only a small proximal part (first dorsal subsegment) of segment A₁.

(iv) In 1 lobe (Specimen E56), it comprised two large tributaries, one from the lateral and the other from the medial aspect of segment A₁. Both joined and then opened into the lateral vein as it crossed the lobar artery.

(d) In the remaining lobe (Specimen M14), it drained into the common stem formed by vein A₁-A₂ and the lateral vein, as their

common stem crossed dorsal to bronchus A₁.

Vein A₁-A₂

Running in interbronchial space A₁-A₂, it was present in all the lobes examined.

The following types of arrangements were found:-

(a) In 12 lobes (Specimens M2, M4, M5, M6, M9, M11, M13, M16, E49, E50, E52, E56), it drained directly into the lobar vein.

(b) In 4 lobes (Specimens M3, M7, M8, M10), it received vein A₁, as already mentioned under vein A₁.

(c) In 1 lobe (Specimen M1), it joined vein A₂-T, opposite and medial to the root of bronchus A₂, to open into the lobar vein by a short common stem.

(d) In 1 lobe (Specimen M14), it drained into the lateral vein.

Vein A₂-T

This vein, as indicated by its name, drained the adjacent parts of segments A₂ and T.

It was found in 17 lobes.

The following arrangements were found:-

(a) In 14 lobes, it drained directly into the lobar vein.

(b) In 1 lobe (Specimen M1), as mentioned already under vein A₁-A₂, it joined the lobar vein in common with vein A₁-A₂.

(c) In 1 lobe (Specimen M4), a vein from T-segment (vein A₃-A₄) crossed medial to the root of bronchus A₃ and joined vein A₂-T to form a common stem before opening into lobar vein.

(d) In 1 lobe (Specimen E56), a vein from T-segment (vein P₃-P₄) joined vein A₂-T, in space A₂-T, after crossing lateral to lobar artery and bronchus to form a common stem before opening into the lobar vein.

Vein A₂

The veins of the right cardiac lobe in the 18 specimens examined are summarised in Table 25.

(+ sign signifies the presence of the vein in the specimen)

CAUDAL TRIBUTARIES				CEPHALIC TRIBUTARIES				No. of Lobes	Details of Specimens
Vein P ₁	" P ₁ -P ₂	Lateral Vein	Vein P ₂ -T	Vein A ₁	" A ₁ -A ₂	" A ₂ -T	" A ₂		
	+	+	+	+	+	+		5	M1, M7, M8, M10, E49
+	+	+	+	+	+	+		2	M2, E50
		+	+	+	+	+		7	M3, M4, M5, M9, M11, M16, E52
	+		+	+	+		+	1	M6
	+	+		+	+	+		1	M13
+		+	+	+	+	+		2	M14, E56
4	9	17	17	18	18	17	1	18	

Frequency of each vein

VEINS OF THE RIGHT DIAPHRAGMATIC LOBE

The Lobar Vein (Fig. 42, Table 26)

The lobar vein, in 17 specimens out of 18, commenced in the region of the terminal end of the lobe. In the distal half of the lobe it was ventral to the lobar stem bronchus among the accessory bronchi, and in the proximal half along the medial or ventro-medial aspect of the lobar bronchus. Multiple minute veins from the m-bronchi join it on its way.

In the 18th specimen (M6), the lobar vein was represented by two veins in the distal half of the lobe, one running along the medial and the other along the ventral aspect of the lobar stem bronchus.

Dorsal Tributaries

Vein D₁-D₂

This vein was constantly present. It was found to drain the whole of segment D₁ in all except 2 lobes, in which a separate vein D₁ was present (vide infra), and the adjoining part of segment D₂ in all the lobes.

Its main tributary, draining the interbronchial space D₁-D₂, proceeds in a medial, cephalic and ventral direction and receives one to two well marked tributaries from the medial aspect of segment D₁. After crossing the lobar stem bronchus dorsally, it joins the lobar vein.

In one of the lobes (Specimen E50), this vein commenced in the dorsal part of segment V₁. It passed medially through interbronchial space D₁-D₂, dorsal to the lobar bronchus, to join the lobar vein.

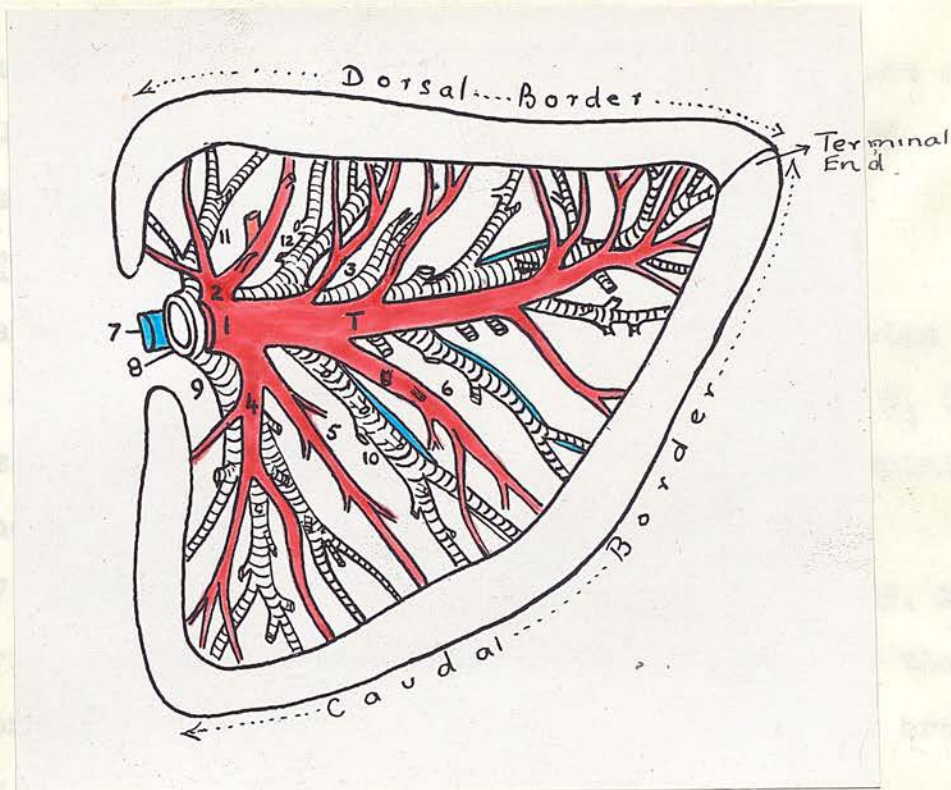


Fig.42 . Venous Drainage of Right Diaphragmatic Lobe of Dog - Medial View (Specimen M5)
Veins, red; Arteries, blue; Bronchi, cross-hatched.

- | | |
|--|--|
| 1. Lobar Vein | 7. Lobar Artery - continuation of Pulmonary Artery |
| 2. Vein D ₁ -D ₂ | 8. Lobar Bronchus |
| 3. Vein D ₂ -T | 9. Bronchus V ₁ |
| 4. Vein V ₁ | 10. Bronchus V ₂ |
| 5. Vein V ₁ -V ₂ | 11. Bronchus D ₁ |
| 6. Vein V ₂ -T | 12. Bronchus D ₂ |

T. Terminal Vein - continuation of Lobar Vein

Vein D₁

A separate vein, D₁, drained only the cephalic part of segment D₁ in two lobes (Specimens M7, M8). It opened independently into the lobar vein.

Vein D₂-T

This vein, present in all the lobes examined, drains segments D₂ and T. Situated between bronchus D₂ and D₃ (the latter belonging to T segment), it is directed in a cephalic, medial and ventral direction.

In 7 lobes out of 18 (Specimens M2, M4, M7, M8, M9, M14, E49), during its course, it crossed at first dorsal to the root of bronchus m₁, and then medial to the lobar stem bronchus to end in the lobar vein.

In one lobe (Specimen E50), vein D₂-T commenced under the costal surface of the lobe by receiving tributaries from segments V₁, V₂ and T. This tributary traversed the space between bronchi D₂ and D₃, from the lateral to the medial side, dorsal to the lobar bronchus and artery, before opening into the lobar vein.

In one specimen (E56), this vein was replaced by a vein which commenced in the T-segment, between bronchi D₃ and D₄. The vein passed ^{cephalically} medial to bronchus D₃, crossing dorsal to the roots of bronchi m₁ and m₂, and then turned medially, cephalically and ventrally to cross the lobar stem bronchus, and drained into the lobar vein.

In one specimen (M14), interbronchial space V₁-V₂ was drained by two veins, one draining the proximal part of the space and joining the lobar vein, and the other draining the distal part of the space into vein V₂-T by crossing it to bronchus V₂.

Ventral Tributaries

Vein V₁

It is a prominent vein which lies medial to the branches of segmental bronchus V₁. It drains the major part of segment V₁. It was found in all the 18 lobes examined.

In 14 lobes (Specimens M2, M3, M4, M5, M8, M9, M10, M11, M13, M14, M16, E50, E52, E56), it joined vein V₁-V₂ near the root of bronchus V₁. The short common stem thus formed was caudal and medial to the segmental bronchus before joining the lobar vein (Fig. 42).

In the remaining 4 lobes (Specimens M1, M6, M7, E49), the vein opened into the lobar vein independently a little cephalic to vein V₁-V₂.

Vein V₁-V₂

Vein V₁-V₂, lying in the corresponding interbronchial space, was present in all the lobes examined.

In 14 lobes, as stated under the description of vein V₁, it received vein V₁. In 18 lobes examined the arrangements were:-

(a) In 15 lobes (Specimens M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M13, M16, E50, E52, E56), it drained directly into the lobar vein. In one of these specimens (M7) it received vein V₂-T which reached it by crossing medial to bronchus V₂.

(b) In 2 lobes (Specimens M1, E49), the vein itself crossed medial to bronchus V₂ to join vein V₂-T.

(c) In the 18th specimen (M14), interbronchial space V₁-V₂ was drained by two veins, one draining the proximal part of the space and joining the lobar vein, and the other draining the distal part of the space into vein V₂-T by crossing medial to bronchus V₂.

Vein V₂-T

This vein was present in all the lobes examined:-

- (a) In 16 lobes (Specimens M1, M2, M3, M4, M5, M6, M8, M9, M10, M16, M11, M13, M14, E49, E52, E56), it joined the lobar vein directly. In one of these lobes (Specimen M6), in which the lobar vein was represented by two veins in the distal part of the lobe, vein V₂-T joined the ventral of the two. In 3 lobes (Specimens M1, M14, E49), it received vein V₁-V₂ which crossed medial to bronchus V₂. In 1 lobe (Specimen M9), it crossed medial to the root of bronchus V₃ before entering the lobar vein.
- (b) In 1 lobe (Specimen M7), the vein crossed medial to bronchus V₂ to join vein V₁-V₂, as mentioned under vein V₁-V₂.
- (c) In the remaining single lobe (Specimen E50), the vein was rudimentary. Part of the drainage of segments V₂ and T has been noted to have been taken up in this specimen by vein D₂-T (vide supra). The distal part of interspace V₂-T was drained by a vein which crossed medial to bronchus V₃ to join the vein draining space V₃-V₄ (a vein belonging to T-segment).

The veins of the right diaphragmatic lobe in 18 specimens examined are summarised in Table 26.

Table 26

VEINS OF THE RIGHT DIAPHRAGMATIC LOBE OF DOG

(in 18 specimens)

(+ sign signifies the presence of the vein
in the specimen)

DORSAL TRIBUTARIES			VENTRAL TRIBUTARIES			No. of Lobes	Details of Specimens
Vein D ₁	D ₁ -D ₂	D ₂ -T	V ₁	V ₁ -V ₂	V ₂ -T		
+	+	+	+	+	+	16	M1, M2, M3, M4, M5, M6, M9, M10, M11, M13, M14, M16, E49, E50, E52, E56.
+	+	+	+	+	+	2	M7, M8.
2	18	18	18	18	18	18	Frequency of each vein

VEINS OF THE INTERMEDIATE LOBE

(Fig. 43, Table 27)

The Lobar Vein

The lobar vein commences at the terminal end of the lobe. It runs under the cephalic border either dorsal or ventral to the m-branches, parallel to the lobar stem bronchus.

Dorsal Tributaries

Vein D₁-T

This vein was present in all the specimens examined. It commences near the caudal end of segment D₁, which corresponds to the caudal end of the lobe. At first it runs dorso-medial to the stem of bronchus D₁. It then passes through space D₁-D₂, crosses dorsal to the lobar stem bronchus and opens into the lobar vein. It collects tributaries from both segments D₁ and D₂.

In one lobe (Specimen E56) vein D₂-D₃, a vein of the T-segment, crossed dorsal to the root of bronchus D₂ to join vein D₁-T.

Vein D₁-T (accessory)

Space D₁-T was drained by an additional small vein, running parallel to vein D₁-T, along its medial (left) side. It ran nearer to bronchus D₂. It received tributaries mainly from the area of bronchus D₂. As it was found to be situated in space D₁-T, in addition to the main vein D₁-T, this vein has been designated as the accessory vein D₁-T. It was present in 9 lobes. In 8 of these (Specimens M1, M2, M11, M14, E49, E50, E52, E56) it drained into the main vein D₁-T, and in 1 lobe (Specimen M16) it opened independently into the lobar vein.

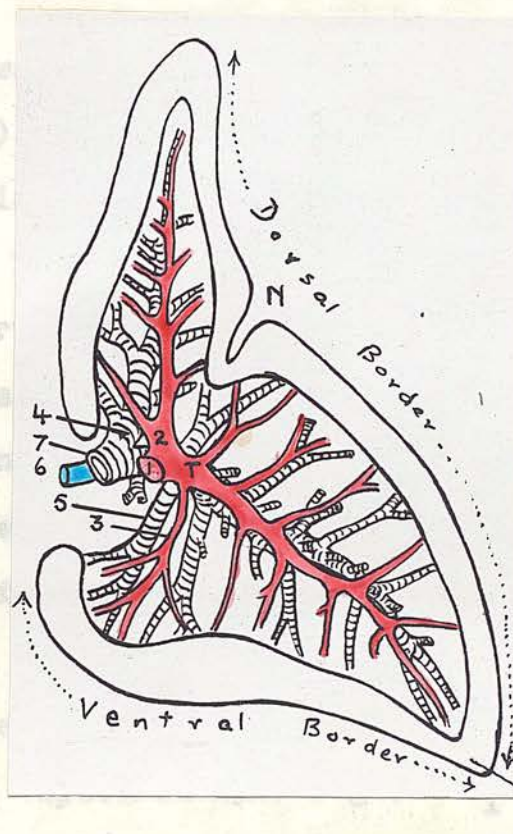


Fig. 4-3 . Venous Drainage of Intermediate Lobe of Dog - Cephalic View (Specimen M5)
Veins, red; Arteries, blue, Bronchi, cross-hatched.

- | | |
|----------------------------|---|
| 1. Lobar Vein | 6. Lobar Artery |
| 2. Vein D ₁ -T | 7. Lobar Bronchus |
| 3. Vein V ₁ -T | T. Terminal Vein - Continuation of Lobar Vein |
| 4. Bronchus D ₁ | N. Notch in Dorsal Border |
| 5. Bronchus V ₁ | |

The veins of the intermediate lobe in 18 specimens examined are summarized in Table 27.

Ventral Tributaries

Vein V₁

Segment V₁ was overdeveloped in 6 lobes (Specimens M1, M3, M8, M9, M14, E50). In each of these lobes one to two large veins drained this segment. In 5 of these lobes (Specimens M1, M8, M9, M14, E50) it drained into vein V₁-T which drains the adjoining parts of segments V₁ and T. In the 6th lobe (Specimen M3), vein V₁ drained into the common stem formed by the union of veins V₁-T and V₂-V₃ (of the T-segment). The tributaries of vein V₁ were situated cephalic to the plane in which the rami of the corresponding segmental bronchus lie.

Vein V₁-T

This vein was absent in 4 lobes (Specimens M4, M7, M10, M11).

In one lobe (Specimen E52) segment V₁ was a segmentellette and the vein, therefore, has been designated as v₁-T.

In 12 lobes (Specimens M1, M2, M5, M6, M8, M9, M13, M14, M16, E49, E50, E56) it traversed space V₁-T and opened directly into the lobar vein. In 3 out of these (Specimens M2, M16, E56) it received vein V₂-V₃, a tributary from T-segment.

In the remaining 1 lobe (Specimen M3) vein V₁-T received vein V₂-V₃, but the common stem so formed received vein V₁ before opening into the lobar vein.

The veins of the intermediate lobe in 18 specimens examined are summarised in Table 27.

Table 27

VEINS OF THE INTERMEDIATE LOBE
(in 18 specimens)

(+ sign signifies the presence of
the vein in the specimen)

DORSAL TRIBUTARIES		VENTRAL TRIBUTARIES			No. of Lobes	Details of Specimens
Vein D ₁ -T	Vein D ₁ -T (accessory)	Vein V ₁	Vein V ₁ -T	Vein v ₁ -T		
+	+	+	+		3	M1, M14, E50
+	+		+		4	M2, M16, E49, E56
+		+	+		3	M3, M8, M9
+					3*	M4, M7, M10
+			+		3	M5, M6, M13
+	+				1*	M11
+	+			+	1	E52
18	9	6	13	1	18	
Frequency of each vein						

* In these specimens segment V₁ was a segmentellette and no vein was recognised in space v₁-T (i.e., v₁-V₂), the drainage being affected by rudimentary vein draining into veins of area V₂.

VEINS OF THE LEFT APICAL
AND THE LEFT CARDIAC LOBES

(Figs. 44 & 45; Table 28)

The veins of the left apical and cardiac lobes will be considered together as the two lobes are partly fused, and there are examples of veins which drain the adjacent territories of both lobes.

The fusion of the two lobes occurs in the region of segments D_1 of the apical and P_1 of the cardiac lobe. The space between their respective bronchi D_1 and P_1 , which will be referred to as space D_1-P_1 , is drained by the corresponding vein D_1-P_1 . This vein, common to both lobes, will be described first.

Vein D_1-P_1 (Figs. 44, 45)

Primarily this vein drains space D_1-P_1 , receiving tributaries from segments D_1 and P_1 , but in the specimens examined it showed a large number of variations. The following arrangements were found:-

(a) In 3 specimens (M1, M9, M16), it was absent. This was associated with the existence of a nearly complete fissure between the apical and the cardiac lobes.

(b) In 9 specimens (M2, M4, M5, M6, M7, M8, M11, E50, E52), after traversing the space, it crossed caudal to the lobar artery and the lobar bronchus of the cardiac lobe to join the corresponding lobar vein. In 6 of these specimens, it received additional tributaries:-

(i) In 3 specimens (M5, M11, E50), it received a prominent tributary from segment D_1 (vein D_1) running under the fissural surface for the diaphragmatic lobe, before joining the lobar vein.

(ii) In 1 specimen (M4), it received a large tributary formed by the union of two veins, one from segment D_1 (vein D_1) and the other from space D_1-D_2 of the apical lobe (vein D_1-D_2). These veins were also found to run under the fissural surface for the diaphragmatic lobe. It also received in this specimen a tributary from segment A_1 (vein A_1), which reached it by crossing lateral to the lobar artery and bronchus.

(iii) In 1 specimen (E52), it received a tributary draining the cephalic part of segment D_1 of the left diaphragmatic lobe (vein D_1 of left diaphragmatic lobe - see page 222).

(iv) In 1 specimen (M7), it received a tributary from the space between bronchus A_1 of the cardiac and bronchus V_1 of the apical lobe, and also a vein from segment P_1 of the cardiac lobe.

(c) In 1 specimen (M10), it crossed bronchus P_1 on its lateral aspect to drain into vein P_1-P_2 .

(d) In 2 specimens (M3, M13), it crossed lateral to the lobar bronchus and artery of the cardiac lobe and then passed medially ventral to the lobar bronchus of the apical lobe to join the lobar vein of the same lobe. On its way it received vein A_1 of the cardiac lobe.

(e) In 1 specimen (E49), the course of vein D_1-P_1 was as in the preceding two specimens but, in addition to vein A_1 , it received vein D_1-D_2 from the apical, and a vein draining segments P_1 and A_1 of the cardiac lobe (vein P_1-A_1).

(f) In 1 specimen (M14, Fig. 45), two veins drained space D_1-P_1 , a lateral and a medial; the former crossed the lobar artery and bronchus of the cardiac lobe on their lateral and the latter on their caudal aspect. The lateral vein, after receiving two tributaries, a vein from segment A_1 of cardiac lobe (vein A_1) and a vein from segment V_1 of apical lobe (vein V_1), passed medially ventral to the lobar stem bronchus of the apical lobe to join the corresponding lobar vein. The medial vein opened directly into lobar vein of the cardiac lobe.

(g) In the remaining 1 specimen (E56), shown in Fig. 9, vein D_1-P_1 was situated opposite the band of lung tissue which is seen to obliterate the major fissure. In this specimen the vein was directed caudally and medially. It received tributaries from segment V_1 of the apical lobe, and segments P_1 and A_1 of the cardiac lobe. It also received a large tributary formed by the union of veins D_1 and D_1-D_2 from the apical lobe, as in specimen M4 described above. The common vein formed by the union of all these tributaries then received a vein from segment D_1 of the left diaphragmatic lobe. The resultant vein then passed caudal to the lobar bronchus of the cardiac lobe and joined the vein of the cardiac lobe. In this specimen the drainage of the venous blood from segment D_1 of the diaphragmatic lobe into vein D_1-P_1 is obviously facilitated by the presence of the band of lung tissue described above.

VEINS OF THE LEFT APICAL LOBE

(Fig. 44, Table 28)

The Lobar Vein

The lobar vein commences in the region of the terminal end of the lobe. It runs parallel to the lobar stem bronchus ventromedial to it.

In 2 lobes, specimens M4 and M11, the vein was formed in the proximal part of the lobe, in the former opposite bronchus d_3 , and in the latter opposite bronchus V_2 , by the union of two large tributaries. Each of these tributaries ran parallel to the lobar bronchus, one dorsomedial and the other ventromedial to it. The position of the lobar vein in the hilum and the mode of its termination have been noted already.

In one specimen (M9), in the distal part of the lobe, the vein was found to run a normal course ventromedial to the lobar stem bronchus, but in the proximal part it passed through inter-bronchial space V_3-V_4 to run across the lateral aspects of the roots of bronchi V_3 and V_2 , lying ventrolateral to the lobar stem bronchus, and then emerged on the medial side again by passing through space V_1-V_2 . It is interesting to note that in this specimen the lobar artery crossed the lobar bronchus from the medial to the lateral side in space D_3-D_4 , so that the lobar vein deviated from its normal course to keep on the side opposite to that of the artery in relation to the lobar stem bronchus.

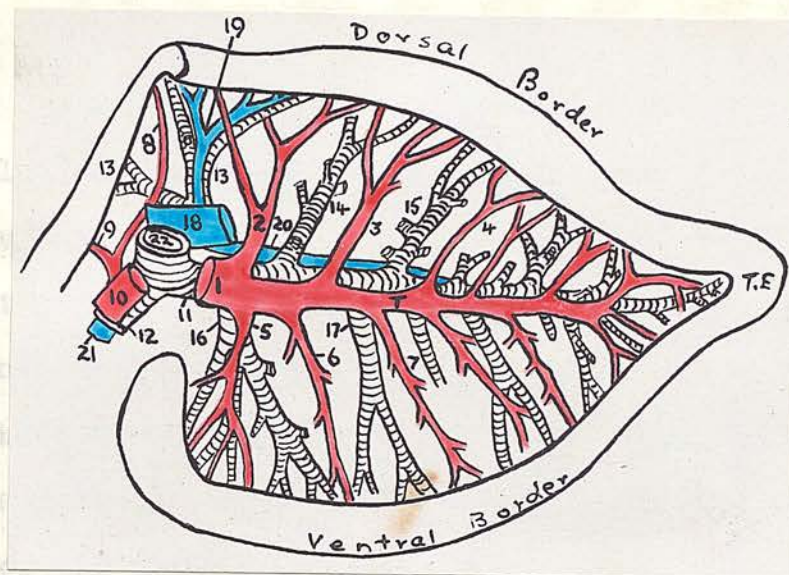


Fig. 44 . Venous Drainage of Left Apical Lobe of Dog - Medial View
(Specimen M5) Veins, red; Arteries, blue; Bronchi, cross-hatched.

- | | |
|---|---|
| 1. Lobar Vein | 13. Bronchus D ₁ |
| 2. Vein D ₁ -D ₂ | 14. Bronchus D ₂ |
| 3. Vein D ₂ -D ₃ | 15. Bronchus D ₃ |
| 4. Vein D ₃ -T | 16. Bronchus V ₁ |
| 5. Vein V ₁ | 17. Bronchus V ₂ |
| 6. Vein V ₁ -V ₂ | 18. Left Pulmonary Artery |
| 7. Vein V ₂ -T | 19. Artery D ₁ |
| 8. Vein D ₁ | 20. Lobar Artery of Left Apical Lobe |
| 9. Vein D ₁ -P ₁ | 21. Lobar Artery of Left Cardiac Lobe |
| 10. Lobar Vein of Left Cardiac Lobe | 22. Common Bronchus of Left Apical and Left Cardiac Lobes |
| 11. Lobar Bronchus of Left Apical Lobe | T. Terminal Vein - continuation of Lobar Vein |
| 12. Lobar Bronchus of Left Cardiac Lobe | T.E. Terminal End. |

crossing medial to br Dorsal Tributaries

Vein D₁ another lobe (Specimen M9), two veins replaced vein

This vein was present in 7 lobes. The arrangements were:-

(a) In 5 lobes (Specimens M4, M5, M11, E50, E56), it drained the caudal part of segment D₁, and was found to run under the pleura covering the fissural surface for the diaphragmatic lobe. It has already been described to end in vein D₁-P₁.

(b) In one lobe (Specimen M16), it drained the ventrolateral part of the segment, and joined vein A₁ of the cardiac lobe to form a common stem, which passed medially ventral to the lobar bronchus of the apical lobe, to enter the corresponding lobar vein. This D₁ to join vein D₁ which drained into vein D₁-P₁.

(c) In the 7th lobe (Specimen M9), the vein was exceptional in running across the lateral aspect of the branches of the segmental bronchus D₁, parallel to the stem of the bronchus. After crossing lateral to the lobar bronchus of the apical lobe, it passed through the angle formed by the lobar bronchi of the cardiac lobe and the apical lobe, to open in the angle of union of the lobar veins of the two lobes.

Vein D₁-D₂

This vein drains and runs between segments D₁ and D₂.

It was absent in 2 lobes. The following arrangements were found:-

(a) In 10 lobes (Specimens M1, M3, M5, M6, M7, M8, M13, M14, M16, E52), it crossed the lobar bronchus on its medial side to drain into the lobar vein.

(b) In 1 lobe (Specimen M10), it was replaced by two veins; one drained the proximal half of the space and opened into the lobar vein as in the preceding 10 specimens; the other drained the distal half of the space and opened into vein D₂-D₃ by

crossing medial to bronchus D_2 .

(c) In another lobe (Specimen M9), two veins replaced vein D_1-D_2 as in the preceding lobe (Specimen M10), but the proximal vein crossed lateral to the lobar bronchus to end in the lobar vein, and the distal vein crossed lateral to bronchus D_2 to enter vein D_2-D_3 .

(d) In one lobe (Specimen M11), it crossed bronchus D_2 on its medial aspect to drain into vein D_2-D_3 .

(e) In one lobe (Specimen E49), it crossed lateral to the lobar bronchus to join vein D_1-P_1 .

(f) In 2 lobes (Specimens M4, E56), it crossed medial to bronchus D_1 to join vein D_1 which drained into vein D_1-P_1 .

Vein $D_1-d_2-D_3$

This vein was present in 2 lobes (Specimens M2, E50). In each of these specimens it commenced in the space between bronchi D_1 and D_3 , and then, passing through the space between bronchi d_2 and D_3 , it opened into the lobar vein after crossing medial to the lobar bronchus. In specimen E50 it received a large tributary from segment D_1 .

Vein D_1-d_2

In specimen M2, in which segments D_1 , d_2 and D_3 were drained by vein $D_1-d_2-D_3$, an additional small vein drained the space between bronchi D_1 and d_2 . It passed medial to the lobar bronchus to join the lobar vein.

Vein D_2-D_3

This vein was present in 7 lobes.

In 6 lobes (Specimens M5, M10, M11, M13, M16, E56), the vein drained into the lobar vein after crossing medial to the lobar bronchus. In 2 of these (Specimens M10, M11), it

received vein D_1-D_2 . In 1 lobe (Specimen M9), the vein received vein D_1-D_2 , and then crossed the lobar stem bronchus on its lateral aspect to end in the lobar vein.

Vein D_2-d_3

In one specimen (E49), the third dorsal bronchus was underdeveloped. The vein draining space D_2-d_3 was identical to vein D_2-D_3 described above, but it has been given a separate designation simply to indicate that d_3 was a segmentellette.

Vein D_2-d_3-T

This vein drained segment D_2 , segmentellette d_3 and the T-segment. It was present in 7 lobes. (Table 28).

In each of these lobes it commenced between segments D_2 and T, d_3 being a segmentellette, and then, passing into space d_3-D_2 , it crossed the lobar bronchus on its medial aspect to enter the lobar vein.

Vein D_3-T

This vein was present in 9 lobes. (Table 28). In each of these it traversed space D_3-T . In 8 it crossed the lobar bronchus on its medial side, and in 1 (Specimen M9) on its lateral side before entering the lobar vein.

Vein d_3-T

In 4 lobes (Specimens M3, M8, M14, E49), a vein drained the adjoining parts of segmentellette d_3 and segment T. It crossed the lobar bronchus on its medial side to join the lobar vein.

Vein D_2-D_3-T

It was present in 1 lobe (Specimen M6).

It commenced in the T-segment, crossed lateral to bronchus D_3

and then traversed space D_2-D_3 to cross the lobar bronchus and join the lobar vein.

It drained part of segment V_2 only and opened into the lobar vein by passing medial to bronchus V_2 .

Ventral Tributaries

Vein V_1

This vein was present in 15 lobes. The arrangements were:-

- (a) In 10 lobes (Specimens M2, M3, M4, M5, M6, M8, E49, E50, E56, M13), it drained variable parts of segment V_1 and by passing medial to bronchus V_1 it drained independently into the lobar vein. In one of these (Specimen M13) it was rudimentary.
- (b) In 3 lobes (Specimens M7, M10, M16), vein V_1 was represented by two veins, a proximal and a distal; each drained independently into the lobar vein. In each of these 3 lobes, segment V_1 was overdeveloped.
- (c) In 1 lobe (Specimen M11), vein V_1 crossed medial to bronchus V_1 to join vein V_1-V_2 .
- (d) In 1 lobe (Specimen M14), in which vein D_1-P_1 was represented by two veins, a lateral and a medial (see page 210), it drained into the lateral vein.

Vein V_1-V_2

This vein was absent in two lobes (Specimens M7, M16)- In both, segment V_1 was overdeveloped.. The arrangements in 16 lobes were:

- (a) In 1 lobe (Specimen M10), the vein was represented by two veins, each opening independently into the lobar vein.
- (b) In the remaining 15 lobes, the space was drained by a single vein which opened directly into the lobar vein.

In one specimen (M11) it received vein V_1 .

Vein V₂

This vein was present in 2 lobes (Specimens M3, E52). It drained part of segment V₂ only and opened into the lobar vein by passing medial to the root of bronchus V₂.

Vein V₂-T

(Table 28)

This vein was present in 15 specimens. In each it opened independently into the lobar vein after traversing the corresponding space.

Vein V₁-V₂-T

In 1 lobe (Specimen M7), segment V₂ was very rudimentary, and a vein lying between segments V₁ and T drained the adjoining parts of these two segments and the segmentellette v₂. The vein opened directly into the lobar vein.

The veins of the left apical lobe in the 18 specimens examined are summarised in Table 28.

Vein P₁

Vein P₁ is a small vein which was found only in 4 lobes. It drained the dorsal part of segment P₁. It ran under the medial surface of the segment. The arrangements were:-
(a) In 2 lobes (Specimens M1, M16), it opened into the lobar vein.

(b) In 1 lobe (Specimen M7), it drained into vein P₁-P₂.

(c) In 1 lobe (Specimen M9), it drained lateral to the lobar artery and bronchus and in this specimen it opened into the lobar vein.

Vein P₁-P₂

This vein was found in all lobes. The following arrangements were found:-

VEINS OF THE LEFT CARDIAC LOBE

(Fig. 45, Table 28)

The Lobar Vein

The lobar vein commences at or near the terminal end of the lobe. It at first runs parallel to the lobar bronchus, in a plane cephalic to the medial border of the lobe and, therefore, cephalic to the accessory m-bronchi under the cardiac surface. In the proximal part of the lobe where m-branches are missing it runs medial to lobar stem bronchus, but in 2 lobes (Specimens E52, E56) it was caudomedial, and in 1 (Specimen M9) cephalic and medial to the lobar bronchus near the hilum.

In one lobe (Specimen M7), in the distal two-thirds of the lobe, the lobar vein was represented by two veins, one running caudal and the other cephalic to the lobar bronchus. The two veins joined to form a single vein opposite bronchus P_3 .

Caudal Tributaries

Vein P_1

Vein P_1 is a small vein which was found only in 4 lobes. It drained the dorsal part of segment P_1 . It ran under the medial surface of the segment. The arrangements were:-

(a) In 2 lobes (Specimens M1, M16), it opened into the lobar vein of the lobe.

(b) In 1 lobe (Specimen M7), it drained into vein D_1-P_1 .

(c) In 1 lobe (Specimen M9), it crossed lateral to the lobar artery and bronchus and in this specimen it opened into the common stem formed by veins P_1-P_2 and P_2-P_3 .

Vein P_1-P_2

This vein was found in all lobes. The following arrangements were found:-

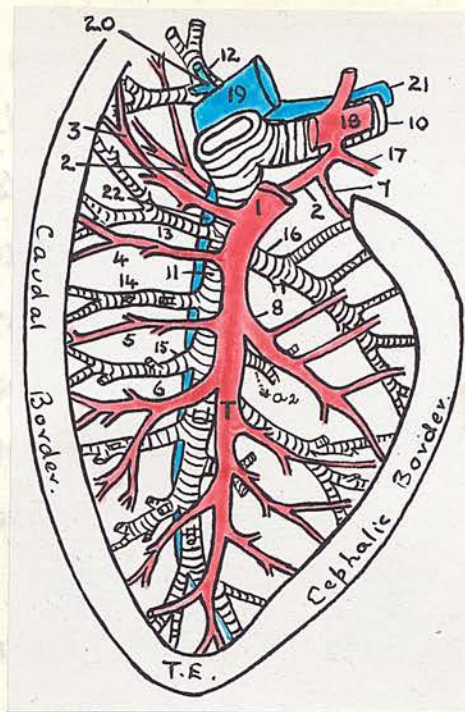


Fig. 45. Venous Drainage of Left Cardiac Lobe of Dog - Medial View (Specimen M14) Veins, red; Arteries, blue; Bronchi, cross-hatched.

- | | |
|--|---|
| 1. Lobar Vein | 13. Bronchus P ₁ |
| 2. Vein D ₁ -P ₁ (Lateral) | 14. Bronchus P ₂ |
| 3. Vein D ₁ -P ₁ (Medial) | 15. Bronchus P ₃ |
| 4. Vein P ₁ -P ₂ | 16. Bronchus A ₁ ⁺ |
| 5. Vein P ₂ -P ₃ | 17. Vein V ₁ of Left Apical Lobe |
| 6. Vein P ₃ -T | 18. Lobar Vein of Left Apical Lobe |
| 7. Vein A ₁ | 19. Left Pulmonary Artery |
| 8. Vein A ₁ -T | 20. Artery D ₁ of Left Apical Lobe |
| 9. Common Bronchus of Apical and Cardiac Lobes | 21. Lobar Artery of Left Apical Lobe |
| 10. Lobar Stem Bronchus of Left Apical Lobe | 22. Lobar Artery of Left Cardiac Lobe |
| 11. Lobar Stem Bronchus of Left Cardiac Lobe | T. Terminal Vein - continuation of Lobar Vein |
| 12. Bronchus D ₁ of Left Apical Lobe | T.E. Terminal End. |

Note: Vein D₁-P₁ is represented by a Lateral and Medial Vein.

(a) In 16 lobes (Specimens M1, M2, M3, M4, M5, M6, M7, M8, M10, M11, M13, M14, M16, E49, E50, E52), it traversed space P_1-P_2 and opened directly into the lobar vein. In Specimen M10, it received vein D_1-P_1 . In Specimen M7, it received a vein which drained the lateral aspect of the dorsal part of segment A_1 , and crossed lateral to the lobar artery and bronchus to pass through space P_1-P_2 and join vein P_1-P_2 . In Specimen M16, vein P_1-P_2 opened so close to vein P_1 that they appeared to open by a common orifice. In Specimen E50, vein P_2-P_3 crossed medial to bronchus P_2 to enter space P_1-P_2 and open into the vein of this space.

(b) In 1 lobe (Specimen M9), vein P_2-P_3 crossed lateral to bronchus P_2 and joined vein P_1-P_2 on the lateral aspect of the lobar artery. The common stem thus formed received vein P_1 and, passing round the cephalic aspect of lobar bronchus, dorsal to the root of bronchus A_1 , opened into the lobar vein.

(c) In 1 lobe (Specimen E56) due to the obliteration of the major fissure (Fig. 9), space P_1-P_2 was found to be drained by a vein which joined the two veins draining the cephalic aspect of the first lateral subsegment of segment V_1 of the left diaphragmatic lobe. The three veins joined to form a vein which opened into the lobar vein of the cardiac lobe by crossing the lobar bronchus on its caudal aspect.

Vein P_2-P_3

This vein was present in 17 lobes. It was absent in Specimen E56.

The following arrangements were found:-

(a) In 9 lobes (Specimens M2, M3, M4, M6, M7, M10, M14, M16, E52) it traversed space P_2-P_3 , and crossed the lobar artery and

bronchus on their fissural (or caudal) aspect to open into the lobar vein.

(b) In 6 lobes (Specimens M1, M5, M8, M11, M13, E49), vein P₃-T crossed medial to bronchus P₃ and joined vein P₂-P₃.

The common stem so formed joined the lobar vein.

(c) In 2 lobes (Specimens M9, E50), vein P₂-P₃ joined vein P₁-P₂ to form a common stem. In one of these (Specimen M9), vein P₂-P₃ crossed bronchus P₂ on its lateral aspect to join vein P₁-P₂ lateral to the lobar artery to form a common stem (see under vein P₁-P₂). In the other specimen (E50), vein P₂-P₃ crossed medial to bronchus P₂ to join vein P₁-P₂ in the corresponding space P₁-P₂.

Vein P₃-T

This vein was also present in 17 lobes, and was absent in specimen E56. The following arrangements were found:-

(a) In 6 lobes (Specimens M1, M5, M8, M11, M13, E49), as mentioned under vein P₂-P₃, this vein joined vein P₂-P₃.

(b) In 9 lobes (Specimens M2, M3, M4, M10, M14, M16, M6, E50, E52), it traversed space P₃-T, crossed the lobar bronchus to enter lobar vein directly. In one of these (Specimen M14), it received vein P₄-P₅, a vein belonging to T-segment.

(c) In 1 lobe (Specimen M9), the vein crossed lateral to the lobar bronchus and artery to open into the lobar vein.

(d) In 1 lobe (Specimen M7), it opened into the caudal of the two veins representing the lobar vein. (See under Lobar Vein, Specimen M7.)

Vein P₂-P₃-T

This vein was found in 1 lobe (Specimen E56). It commenced in this specimen in the T-segment and, proceeding under the

caudal surface of the lobe, received tributaries from the T-segment, segmentallette p_3 and segment P_2 . It drained directly into the lobar vein.

Cephalic Tributaries

Vein A_1

Vein A_1 was present in 12 lobes.

In each of these lobes it was found to drain the dorsal part of the segment by running under the pleura on the medial surface, the exact extent of the area drained depending upon the size of the segment. In Specimens M3, M7, M8 and M10, segment A_1 was overdeveloped and the vein was of a large size.

The following arrangements were found:-

(a) In 4 lobes (Specimens M3, M4, M13, E49), the vein drained into vein D_1-P_1 .

(b) In 1 lobe (Specimen M14), in which vein D_1-P_1 was represented by a lateral and a medial vein, it drained into the lateral of the two veins (see under vein D_1-P_1).

(c) In 1 lobe (Specimen M16), vein A_1 joined vein D_1 of the apical lobe, and the common stem then drained into the lobar vein of the apical lobe (see under vein D_1 of the left apical lobe).

(d) In 6 lobes (Specimens M1, M2, M7, M8, M10, E50), the vein passed medial to the root of bronchus A_1 and opened into the lobar vein of the cardiac lobe. In one of these six specimens (M7), there was also a large tributary from the lateral aspect of segment A_1 which crossed lateral to the lobar artery to open into vein P_1-P_2 (see vein P_1-P_2).

Vein A₁-T

It will be noticed from Table 6, Columns 5A, 5B, 5C and 6 that bronchi A₁ and A₂ of the left cardiac lobe are very variable in their size. Therefore, vein A₁-T, i.e., the vein between bronchi A₁ and A₂ (or A₃ if A₂ is rudimentary), was found to be very variable in size, in direction and in the extent of the area it drained in each lobe. Larger tributaries came either from segment A₁ or segment T, depending upon their relative sizes. In 17 lobes in which it was present as a single artery, it traversed space A₁-T and then opened directly into the lobar vein. In the 18th lobe (Specimen M3) it was represented by two veins each opening independently into the lobar vein.

Vein P₁-A₁

In one specimen (E49), this vein, which belongs to neither of the two classes of tributaries - caudal and cephalic, was a tributary of vein D₁-P₁. It drained the area in the angle between bronchi P₁ and A₁ of the cardiac lobe overlying the lobar stem bronchus and the artery. It was a small vein.

The veins of the cardiac lobe in all the specimens examined are summarised in Table 28.

(+ sign signifies the presence of the vein in the specimen)

Frequency of each vein

VEINS OF THE LEFT DIAPHRAGMATIC LOBE
(Fig. 46, Table 29)

The Lobar Vein

Typical arrangement was found in 17 lobes in which the vein commenced near the terminal end. In these specimens it first runs ventral to the lobar stem bronchus among the accessory branches, and then, in the proximal part of the lobe, it assumes a position medial to the lobar stem bronchus.

In one lobe (Specimen M3), beyond the origin of bronchus V₂, it was represented by two veins, one running dorso-medial, and the other ventral to the lobar bronchus.

Dorsal Tributaries

Vein D₁

This vein was present in 2 lobes (Specimens E52, E56). It drained the cephalic part of segment D₁, and in each of the 2 lobes it crossed the stem of the main pulmonary artery to drain into vein D₁-P₁.

Vein D₁-D₂

This vein lies in the interbronchial space D₁-D₂. It was present in 17 lobes, and absent in 1 lobe (Specimen M10). The following arrangements were found:-

- (a) In 15 lobes, it drained the whole of segment D₁ and the adjoining part of segment D₂.
- (b) In 2 lobes (Specimens E52, E56), the cephalic half of segment D₁ was drained by vein D₁, described above; vein D₁-D₂ drained only the adjoining parts of segments D₁ and D₂.

The vein receives one to two prominent tributaries from segment D₁ either from the medial or the lateral aspect.

in all specimens the vein crossed the other branches opposite space Terminal End.

Vein D₂-D₃

This vein

lobes it was

draining the

crossed dorsal

vein.

Vein D₃-T

This vein

It drains

traverses the

crossing the lobar bronchus dorsally, joins the lobar vein.

In 4 lobes out of these specimens

Fig.46 . Venous Drainage of Left Diaphragmatic Lobe of Dog - Medial View (Specimen M5) Veins, red; Arteries, blue; Bronchi, cross-hatched.

- | | |
|--|---|
| 1. Lobar Vein | 10. Bronchus D ₂ |
| 2. Vein D ₁ -D ₂ | 11. Bronchus D ₃ |
| 3. Vein D ₂ -D ₃ | 12. Bronchus V ₁ |
| 4. Vein D ₃ -T | 13. Bronchus V ₂ |
| 5. Vein V ₁ | 14. Lobar Artery - continuation of Pulmonary Artery |
| 6. Vein V ₁ -V ₂ | 15. Artery D ₁ |
| 7. Vein V ₂ -T | 16. Artery V ₁ |
| 8. Lobar Bronchus | T. Terminal Vein - continuation of Lobar Vein |
| 9. Bronchus D ₁ | |

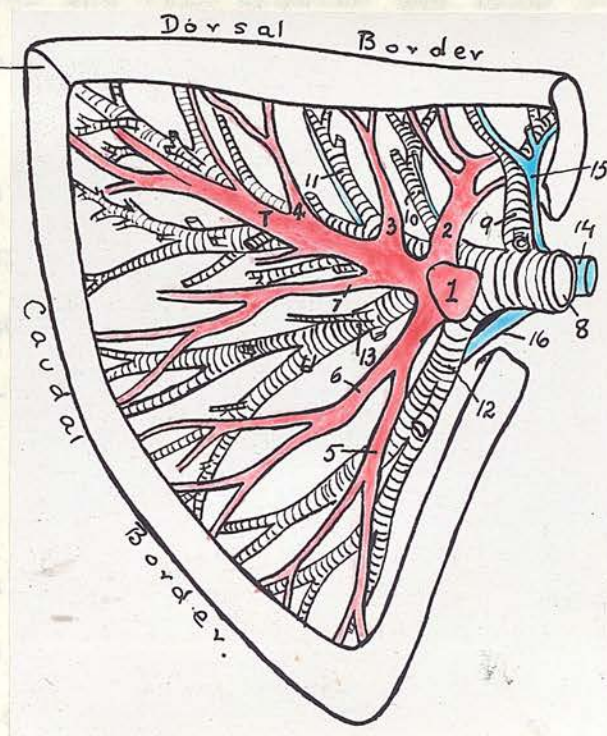
with the other dorsal bronchi, but its area of distribution

was so much displaced laterally that segment D₂ came directly

into contact with the area D₁ (part of T-segment).

The three

bronchi, D₁, D₂ and D₃ diverged from their origin in a tripodic



In all specimens the vein crossed the lobar bronchus opposite space D_1 - D_2 to open into the lobar vein.

Vein D_2 - D_3

This vein was present in 16 lobes. In each of these lobes it was situated in the interbronchial space D_2 - D_3 , draining the adjoining parts of both segments. The vein crossed dorsal to the lobar bronchus to open into the lobar vein.

Vein D_3 -T

This vein was present in 17 lobes.

It drains the adjoining parts of segments D_3 and T. It traverses the corresponding interbronchial space and, after crossing the lobar bronchus dorsally, joins the lobar vein.

In 4 lobes out of these (Specimens M1, E49, E50, M10), it received a vein from the T-segment (vein D_4 - D_5) which crossed medial to bronchus D_4 to join it.

In Specimen M14 a prominent vein, receiving tributaries from the dorsal parts of segments V_2 and V_3 , crossed dorsal to the lobar artery and the lobar stem bronchus to join this vein.

In Specimen M3 the lobar vein, distal to the middle of the lobe, was represented by two veins. Vein D_3 -T in this lobe opened into the dorsal of the two veins.

Vein D_2 - D_3 -T

This vein was present only in one lobe (Specimen M2).

Bronchus D_3 , in this lobe, at its origin was in series with the other dorsal bronchi, but its area of distribution was so much displaced laterally that segment D_2 came directly into contact with the area D_4 (part of T-segment). The three bronchi, D_1 , D_2 and D_3 diverged from their origins in a tripodic

fashion. The vein was situated between segments D_2 , D_3 and the area of distribution of bronchus D_4 so that it drained all three areas.

Vein D_1 - D_2 - D_3

This vein, too, was present in 1 lobe (Specimen M10).

Bronchus D_2 was displaced outwards peripherally, just as bronchus D_3 , described under vein D_2 - D_3 -T, was displaced in Specimen M2. The vein drained all three segments D_1 , D_2 and D_3 . It crossed the lobar bronchus dorsally and drained directly into the lobar vein.

Ventral Tributaries

Vein V_1

This is a large vein which was found in all lobes examined.

It drains the major cephalic part of segment V_1 . The vein with its tributaries lies in a plane medial to the bronchi of the segment. The following arrangements were found:-

(a) In the majority of lobes (15 out of 18) it was found to end in vein V_1 - V_2 at a variable distance from the lobar vein.

In one specimen (M14) it joined the proximal of two veins draining space V_1 - V_2 .

(b) In the remaining 3 lobes (Specimens M6, M8, M10), it crossed medial to the root of bronchus V_1 to join the lobar vein independently.

In Specimen E52 three well marked tributaries drained segment V_1 into vein V_1 - V_2 .

Vein V_1 - V_2

This vein was present in all the specimens examined. It drains the adjoining parts of segments V_1 and V_2 and opens directly into the lobar vein.

In 15 lobes, as already mentioned, it received vein V_1 . In 2 of these 15 (Specimens M1, E50), and in another (Specimen M8) vein V_2 -T, after crossing medial to bronchus V_2 , joined vein V_1 - V_2 .

In another 1 lobe out of the 15 (Specimen M14) mentioned above, vein V_1 - V_2 was represented by two veins, a proximal and a distal. The proximal vein received vein V_1 , as mentioned above, under vein V_1 . The distal vein joined vein V_2 -T opposite the root of bronchus V_2 .

Vein V_2 -T

Vein V_2 -T was present in all the lobes examined. It traversed space V_2 -T in all. In 17 lobes it opened into the main lobar vein. In the remaining single specimen (M3) the vein was rudimentary and drained into the ventral of the two veins which represented the lobar vein in the distal half of the lobe. The following arrangements were found:-

(a) In 4 lobes (Specimens M1, M8, M14, E50), it crossed bronchus V_2 near its root on its medial aspect to join vein V_1 - V_2 .

(b) In 13 lobes (Specimens M2, M4, M5, M6, M7, M9, M10, M11, M13, M16, E49, E52, E56), it drained independently into the lobar vein. It received larger tributaries from segment V_2 and smaller ones from the T-segment.

(c) In 1 lobe (Specimen M3), just beyond the origin of bronchus V_2 , the lobar vein was represented by two veins, one running dorsomedial to the lobar bronchus and the other ventral to it. The ventral of the two veins traversed the dorsal part of space V_2 -T. In addition to receiving two large veins from segment V_2 opposite space V_2 -T, it received

THE MORPHOLOGICAL BASIS FOR COMPARISON OF BRONCHO-
PULMONARY SEGMENTS

A review of the available literature has not revealed any clear statement of the principles on which homology may be determined between bronchi either in the two opposite lungs of the same animal, or between bronchi of corresponding lungs of two different mammals.

Any principles of homology utilised in this comparison should be applicable not only to segments of right and left side, but also between segments of a lung of one animal with those of the lung of another.

Two fundamental principles involved in the establishment of homology between any two organs are:- (a) "the morphological identity" which "must be proved beyond dispute" and (b) "a similar development" which is "the great and essential test". (Cunningham's Text Book of Anatomy - 9th Ed., 1951)

SECTION III

COMPARISON -

MAN AND DOG

Here, however, we are dealing not with the lungs as organs but with their smaller anatomical units, the lobes and the broncho-pulmonary segments. This demands a consideration of the above-mentioned principles of homology with regard to their application to these small units. It is unnecessary to point out that homology between the lobes and broncho-pulmonary segments is synonymous with homology between the bronchi supplying them.

Hitherto, interest appears to have been confined to homologies between the right and the left lungs as far as the principal branches arising from the two main bronchi are concerned - such as homologies of the bronchi of right upper and middle lobes, and those of the left upper lobe, and also

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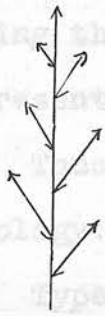
the homologue of cardiac bronchus on the left side.

When the right upper and the right middle lobes of human lung, as commonly believed, are said to be homologous with the areas supplied by the upper division bronchus and the lingular bronchus of the left upper lobe respectively, it is obviously the morphological and topographical resemblance alone on which this opinion is based.

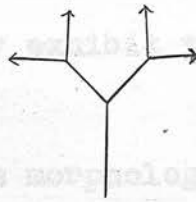
On a similar basis is determined the homology between the bronchopulmonary segments of the right and left human lungs. The second principle of homology, viz., "similarity of development", appears to have been assumed without adequate consideration because in general all bronchi "develop similarly".

However, two bronchi, despite appearing to be morphologically similar, may be dissimilar in one fundamental respect, i.e., they may belong to two different generations of bronchi. For perfect homology, the two bronchi should not only be morphologically similar but should also belong to the same generation of bronchi. Only then would the two criteria of homology be adequately fulfilled.

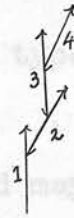
This brings us to a consideration of what may be meant by the term "generation". Opinions have so far differed with regard to the mode of division of bronchi, which, according to Aeby (1880), is "strictly monopodial", according to Ewart (1889) dichotomous, and according to Justesen (1900) quoted by Miller (1950), "sympodial". These modes are diagrammatically represented in Fig. 47 after Lowson (1945).



Monopodial



Dichotomous



Sympodial

Fig. 47. Types of Branching
(After Lowson - 1945)

For a clear understanding of the term "generation" it would be necessary to define it in the light of the true mode of division. However, irrespective of what is the true mode of division, it cannot be denied that each branch in the bronchial tree is the product of a division and that each division results in two branches of the same generation.

Thus the first division in the bronchial tree, i.e., the tracheal bifurcation, results in the right and the left main bronchi, each belonging to the first generation. The second division on the right side results in the right upper lobe bronchus and the "bronchus intermedius" (of Ewart), each a 2nd generation bronchus. The second division on the left side results in two bronchi, left upper lobe bronchus and the lower lobe bronchus, each of second generation. The generations of all bronchi can thus be worked out counting from the tracheal bifurcation.

It may be assumed, unless and until it is proved otherwise, that in an adult bronchial tree, the order in which the bronchi originate along a bronchial stem represents the successive generations in the order in which they made their appearance

during the process of development and each successive branch represents a new generation. Thus two bronchi may exhibit the following four types of homology:-

Type I - They may be morphologically similar and may belong to the same generation.

Type II - They may be morphologically dissimilar and may belong to the same generation.

Type III - They may be morphologically similar and may belong to different generations of bronchi.

Type IV - They may be morphologically dissimilar and may belong to different generations of bronchi.

In Type IV the question of homology does not arise.

Types II and III would be examples of partial homology, and in Type I the homology would be truly perfect.

In order to illustrate the foregoing the following examples may be considered in the lungs of the dog:-

All right apical lobes are similar morphologically. They are constantly supplied by the first branch of the right main bronchus (2nd generation). They are, therefore, absolutely homologous.

Inside the right apical lobe of each dog, the bronchi arise from the lobar stem bronchus in a certain sequence. Referring to Chart I of the right apical lobe, it will be noticed that bronchus P is the first branch to arise in each of the lobes. It belongs to the 3rd generation. It supplies corresponding areas of the lobes and, therefore, offers another example of absolute homology.

In each of 33 lobes out of 37 examined, (excluding Specimens

M3, M4, M6, M7), the second branch of the lobar stem bronchus is D_1 (of 4th generation), and as it supplies in each lobe a topographically similar area, all D_1 bronchi are perfectly homologous in these 33 lobes. Similarly bronchus V_1 , the third branch and of 5th generation in each of the same 33 lobes, provides an example of true homology.

Doubt arises in the case of the remaining 4 lobes (Specimens M3, M4, M6, M7), in each of which bronchi D_1 and V_1 originate opposite each other. Such few incidental cases, however, may be considered not to influence the homology materially, and, therefore, in nearly all the lobes bronchi P, D_1 and V_1 may be considered to provide examples of perfect homology - Type I homology.

The fourth bronchus in each lobe, i.e., of 6th generation, is indicated in column 4 of Chart I. It will be seen that in some lobes the 4th bronchus to arise is D_2 (or d_2), as in Specimens M8 and M3; while in others it is V_2 (or v_2), as in Specimens E54 and E15. Thus bronchus D_2 becomes developmentally homologous to bronchus V_2 in these two specimens, yet morphologically and topographically they are dissimilar because they belong to opposite series of bronchi. This example conforms to Type II homology given above.

On the other hand bronchus D_2 is the 4th branch in Specimen M8 and 5th in Specimen M14. Thus in these 2 specimens, bronchi D_2 are developmentally dissimilar but morphologically similar. This example conforms to Type III homology.

Homology between two bronchi may thus be expressed in the following terms:-

(1) Bronchi exhibiting perfect homology (subsequently also

referred to as complete or absolute homology).

(2) Bronchi exhibiting partial homology:

(a) morphologically similar and developmentally dissimilar.

(b) morphologically dissimilar and developmentally similar.

The principles, discussed above, will be employed for establishing homology between different areas of lungs of dog and of man.

Doubt, however, arises in determining the generations of bronchi when two branches originate from the parent stem at the same level or in the case of "trifurcations", frequently described in the human lung. These will be expressed in terms of alternative generation to which each bronchus would belong if they arose distinctly apart. This appears justified in view of Ewart's and Brock's interpretation of trifurcations as being the result of two rapid bifurcations.

branchus supplies the left upper lobe in man, and the left apical and cardiac lobes in the dog. This branch divides into two smaller branches; in man into the upper division bronchus and the lingular bronchus, and in dog into the bronchus for the apical and the cardiac lobes. Thus the areas supplied by the upper division bronchus and the lingula in man correspond respectively to the apical and the cardiac lobes in dog. The continuation of the left main bronchus supplies the corresponding lower lobe in man and the diaphragmatic lobe in dog.

From the foregoing the homology between the fissures is self-evident. The oblique fissures of the human lungs correspond to the major fissures, and the horizontal fissure

COMPARISON BETWEEN THE EXTERNAL MORPHOLOGY
OF THE LUNGS OF MAN AND OF DOG

(Figs. 48A, 48B, 49A, 49B, 50, 51)

A comparison of the external morphology of the lungs of man and of dog is necessary as a basis for further detailed comparison.

It is easy to determine the homology between the lobes of the corresponding lungs.

The upper and the middle lobes of the right human lung correspond to the right apical and the cardiac lobes of the dog, as they are served by the first and the second branches of the right main bronchus respectively. The continuation of the right main bronchus supplies the lower lobe in man, and the diaphragmatic and the intermediate lobes in the dog. Together the latter two, therefore, correspond to the former.

On the left side, the first branch of the left main bronchus supplies the left upper lobe in man, and the left apical and cardiac lobes in the dog. This branch divides into two similar branches; in man into the upper division bronchus and the lingular bronchus, and in dog into the bronchus for the apical and the cardiac lobes. Thus the areas supplied by the upper division bronchus and the lingula in man correspond respectively to the apical and the cardiac lobes in dog. The continuation of the left main bronchus supplies the corresponding lower lobe in man and the diaphragmatic lobe in dog.

From the foregoing the homology between the fissures is self-evident. The oblique fissures of the human lungs correspond to the major fissures, and the horizontal fissure

of right human lung to the right minor fissure in the dog. The minor fissure of the left lung, and the sagittal fissure separating the diaphragmatic and the intermediate lobes, are two additional fissures in the dog. The former, by its position, may be considered a deep "lingular" notch. The lingular notch in the human lung, however, is known to be inconstant in its position.

The external morphology of the lungs is closely related to the shape of the thoracic cavity. The differences between the thorax of man and other mammals are best expressed by quoting Smyth (1949):-

".... in a pronograde mammal such as a cat or dog, the thorax is narrow, short ventrally and very long dorsally, so that the diaphragm is very oblique, whereas in man the thorax is short posteriorly and relatively long anteriorly so that the diaphragm is almost horizontal, and in order to conform with weight distribution in the erect position, the anteroposterior diameter is reduced especially above and the transverse diameter greatly increased. Furthermore, the heart in pronograde mammals occupies a different position to that of man. It lies more cephalad, more ventrally and is more centrally placed. Thus it does not encroach very much on the space occupied by the lungs. In man, however, the shape of whose thorax is different, the heart occupies a position more caudal and more dorsal than that obtaining in other mammals, and further, it is rotated more to the left."

In the human lungs the most prominent feature, in conformity with the shape of the thorax, is the lateral expansion. This results in the lobes becoming more voluminous, and the dorsal borders very much thicker. The expansion has also affected the apices which become blunt and rounded to fit into the dome-shaped hollow of the cervical pleura.

The changes in the dimensions of the human thorax have also led to a relative shortening of the dorsal and elongation of the ventral borders. The more caudal position of the heart

in man has resulted in the obliteration of the space that contains the intermediate lobe in the dog. This is associated with the disappearance of the intermediate lobe as a separate entity.

The above changes are obviously accompanied by a reorientation and a remoulding of the lobes in the thoracic space. Consequently the relative positions of the interlobar fissures have undergone a corresponding change. This can be appreciated by referring to Figs. 48A, 48B, 49A and 49B.

In each human lung the dorsal end of the oblique fissure is situated nearer the apex of the lung than are the corresponding ends of the major fissures of the dog. The latter have already been seen to commence about the middle of the dorsal borders. This results in a greater obliquity of these fissures in the human lungs, which in the dog are disposed more dorso-ventrally. The dorsal borders of the upper lobes in man are, therefore, relatively shorter, and of the lower lobes relatively longer than the dorsal borders of the corresponding lobes of the dog.

Comparing the ventral aspects of the lung (Figs. 50, 51), the most noticeable difference is the complete absence of the cardiac notch in the right human lung which in the dog is a constant prominent feature. This appears to be the result of a "shifting" of the ventral end of the upper lobe in a caudal direction to meet the ventral end of the middle lobe. This is associated with a ventro-dorsal direction of the horizontal fissure, the corresponding fissure in the dog being directed ventro-cephalically.

The upper lobe thus takes a greater part in the formation

of the ventral border than does the apical lobe of the dog.

A comparison of the medial surfaces of the lungs may be made by studying Figs. 48 and 49 with the assistance of Tables 30 and 31.

Table 30

COMPARISON OF THE FEATURES OF THE MEDIAL SURFACE
OF THE RIGHT LUNG OF DOG AND OF MAN

<u>Feature</u>	<u>Dog</u>	<u>Man</u>
Paravertebral surface	Narrow and narrow Cephalic to the hilum	Broad and broad Ventral and slightly cephalic
Tracheal impression	Dorsal and cephalic to the hilum	Cephalic to the hilum
Impression of the cephalic vena cava (superior vena cava in man)	Cephalic and slightly dorsal to the hilum not pronounced	Ventral to the hilum
Impression of vena azygos	Dorsal to the hilum	Dorsal and cephalic to the hilum
Thymic area	Almost cephalic to the hilum, near apex	Almost ventral to the hilum, farther away from apex
Cardiac impression	Ventro-cephalic to the hilum Situated on apical, cardiac and intermediate lobes	Ventro-caudal to the hilum Situated on upper, middle and lower lobes
Impression of the caudal vena cava (inferior vena cava in man)	Ventral and slightly caudal to the hilum	Caudal to the hilum

corresponding lobes of the dog. This "rotation" when viewed from the medial aspect has taken place in an antero-lateral direction on the right and in a clockwise direction on the left side - the right lung, relative to the position of the corresponding lobe of dog, having been displaced in

Table 3/

COMPARISON OF THE FEATURES OF THE MEDIAL SURFACE
OF THE LEFT LUNG OF DOG AND OF MAN

<u>Feature</u>	<u>Dog</u>	<u>Man</u>
Paravertebral surface	Narrow	Broad and broad
Area for oesophagus and main blood vessels arising from the arch of aorta	Dorso-cephalic to the hilum (dorsal to apex)	Cephalic to the hilum (ventral to apex)
Thymic area	Cephalic to the hilum	Ventral and slightly cephalic to the hilum
Impression of the arch of aorta	Due to the cephalic position of the heart, the impression is not pronounced	The impression is deep and pronounced
Cardiac impression	Ventral to the hilum	Ventro-caudal to the hilum
	Situated on apical, cardiac and diaphragmatic lobes	Situated on upper and lower lobes (associated with disappearance of area for the intermediate lobe depicted in Fig. 17A)

From the foregoing comparison it is concluded that each of the right and the left upper lobes of the human lungs appears to have undergone a "rotation" as compared to the corresponding lobes of the dog. This "rotation" when viewed from the medial aspect has taken place in an anti-clockwise direction on the right and in a clockwise direction on the left side - the right middle lobe, relative to the position of the corresponding lobe of dog, having been displaced in a

caudal direction. The "rotation" is associated with a displacement of the mediastinal structures in the same direction as is obvious from the comparison of mediastinal impressions on the two lungs.

In addition it will be noticed that the shortening of the dorsal borders has occurred more in the region of the upper lobes than in the lower lobes.

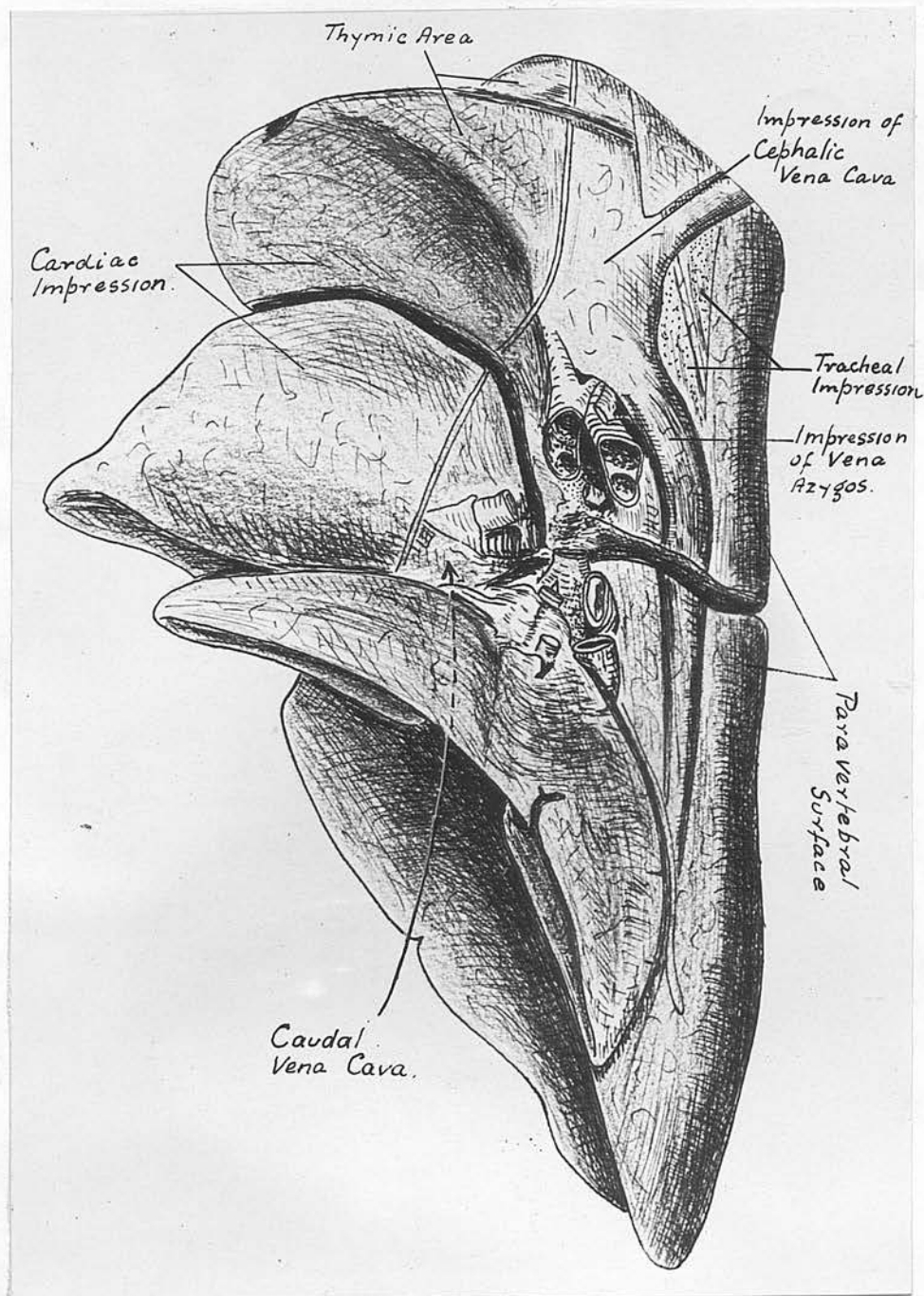


Fig. 4-8 A.

Drawing of Medial View of Right Lung of Dog, hardened in situ. (Specimen M15).

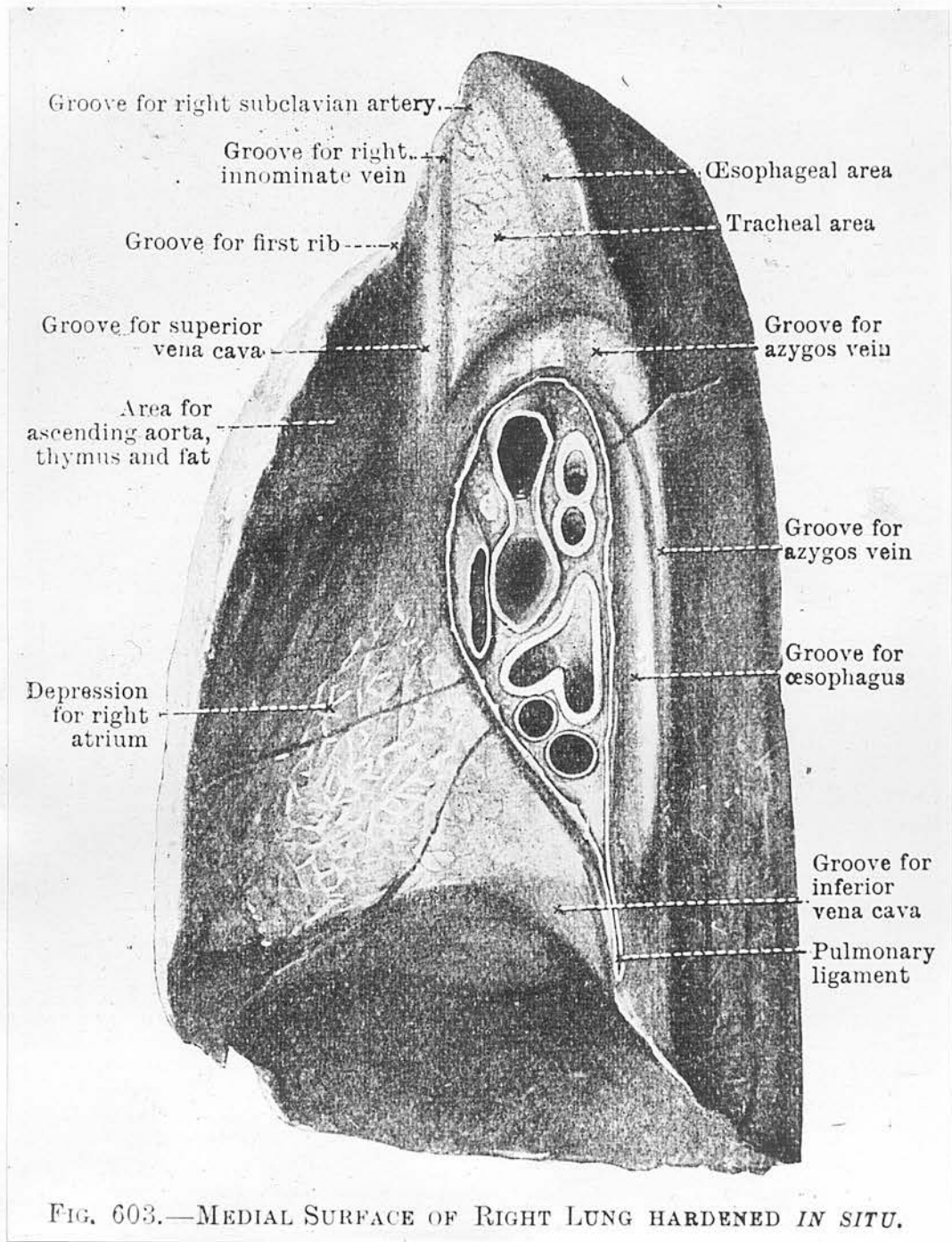


Fig. 48 B.

Medial View of Right Human Lung. (After Cunningham's
Text Book of Anatomy, 1951 — 9th Ed.)

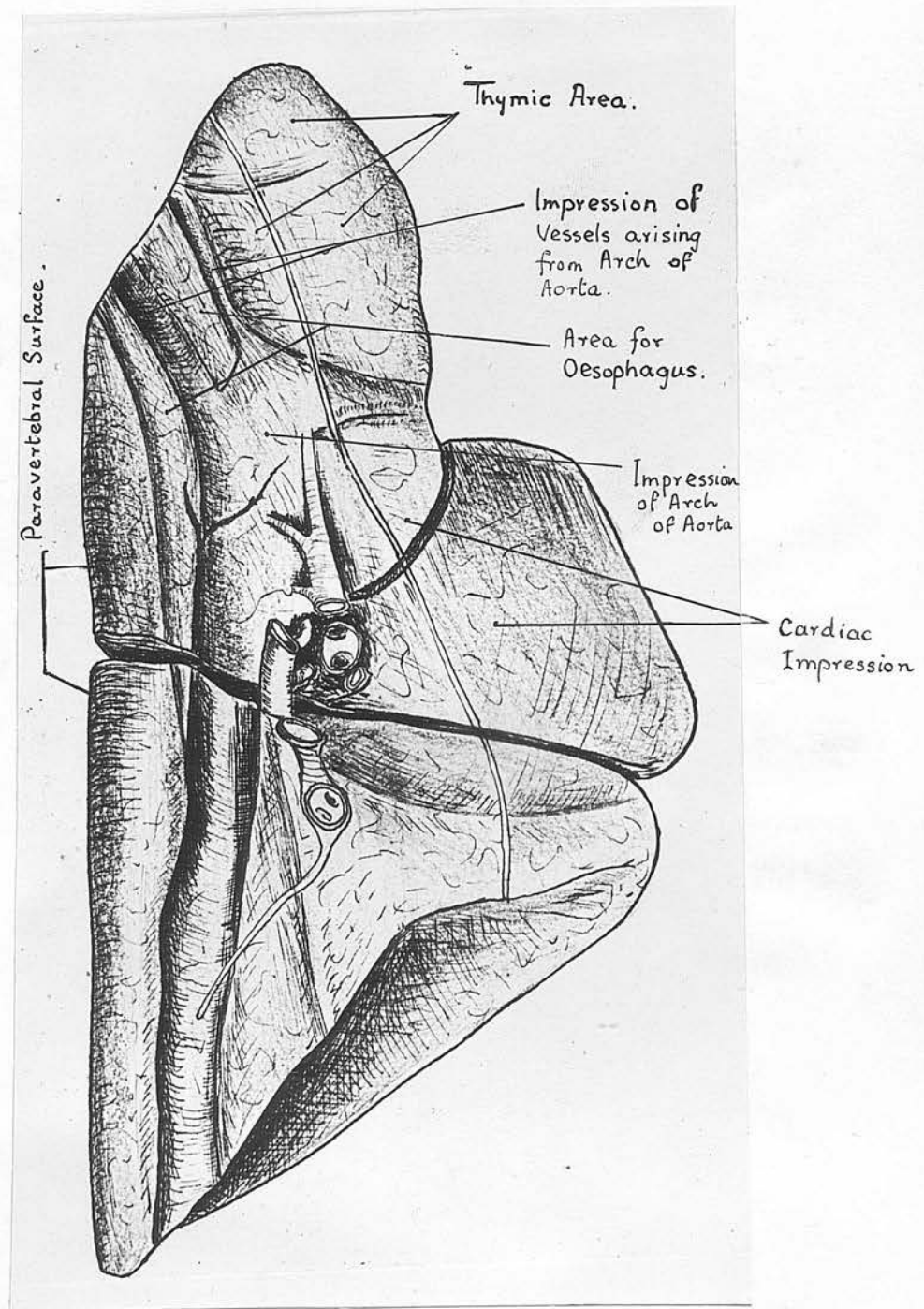


Fig 49. A.
 Drawing of Medial View of Left Lung of
 Dog, hardened in situ. (Specimen M15)

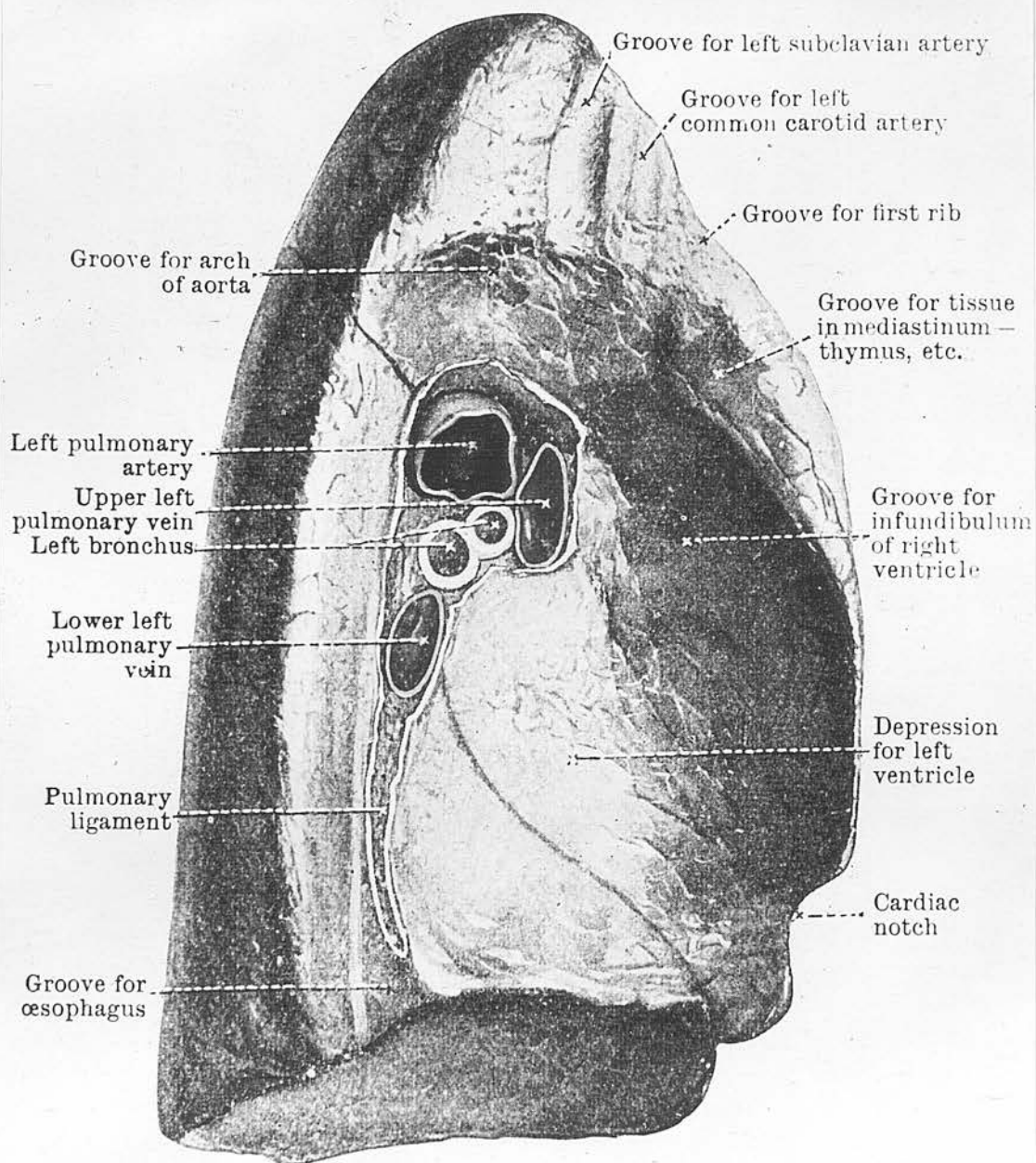


FIG. 602.—MEDIAL SURFACE OF LEFT LUNG HARDENED *IN SITU*.

Fig. 49 B.

*Medial View of Left Human Lung. (After
Cunningham's Text Book of Anatomy, 1951-9th Ed.)*

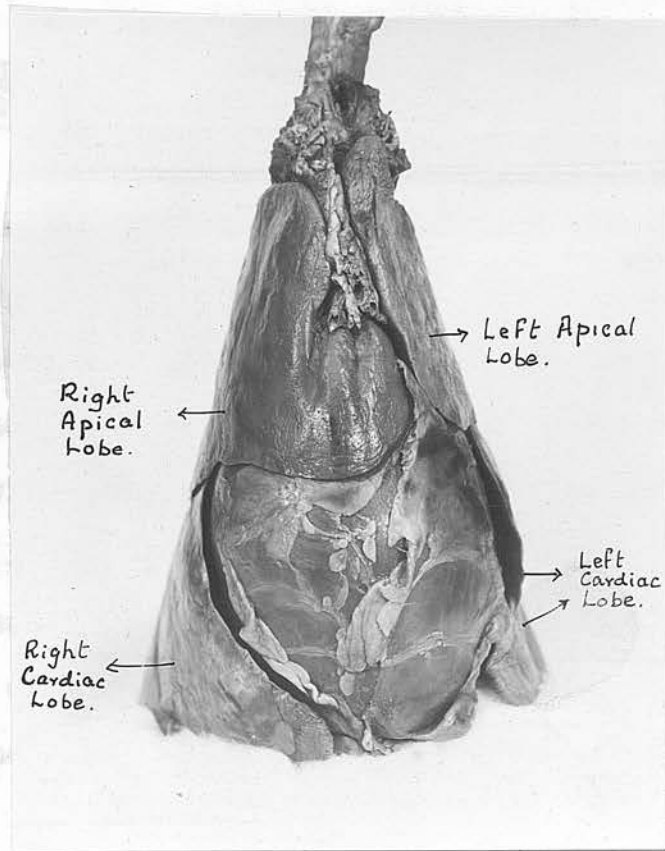


Fig. 50 . Ventral view of a pair of Lungs of Dog (hardened in situ).

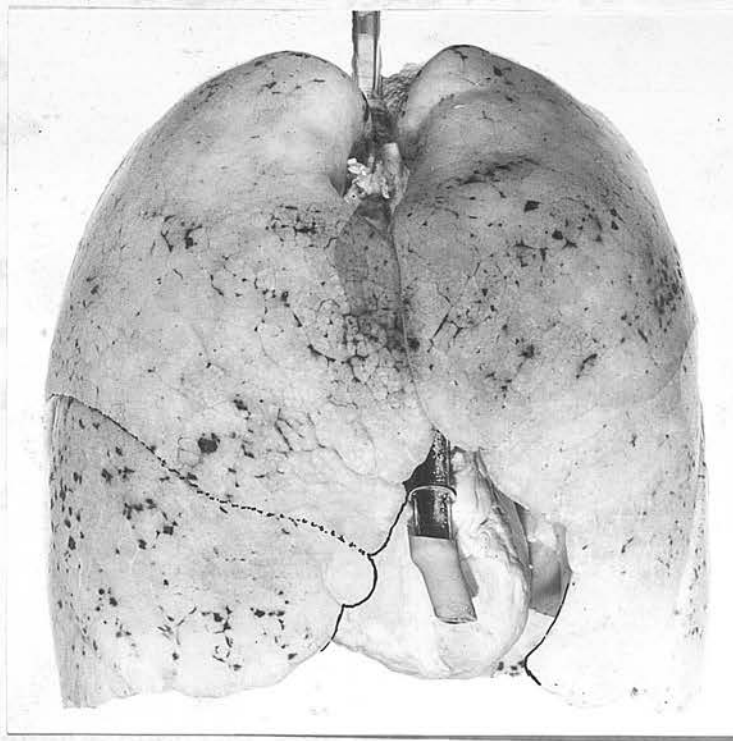


Fig. 51 . Ventral view of a pair of Human Lungs.

MORPHOLOGICAL COMPARISON OF THE LOBES AND THE
BRONCHO-PULMONARY SEGMENTS OF THE LUNGS
OF MAN WITH THOSE OF THE DOG

Excellent coloured illustrations of the lobes of the human lungs, in which the broncho-pulmonary segments have been injected, are given by Brock in his book, "The Anatomy of the Bronchial Tree". These illustrations, which are in agreement with the drawings of the "prevailing patterns" given by Boyden (1949), and which illustrate the surface projections of the segments, have been made the basis of morphological comparison of the lobes and segments of the human lungs with those of the dog. (Figs 52A, 53A, 54A, 55A, 56A, 57A, 59A, 60A, 61A, 62A)

Right Upper Lobe of Human and Right Apical
Lobe of Dog's Lung

(Figs. 52A, 52B, 53A, 53B)

Each of the right upper lobe of human and the right apical lobe of dog possesses identical surfaces indicated below:-

<u>Man</u>	<u>Dog</u>
Costal surface	Costal surface
Mediastinal surface	Mediastinal surface
Fissural surface for the lower lobe	Fissural surface for the diaphragmatic lobe
Fissural surface for the middle lobe	Fissural surface for the cardiac lobe

The two fissural surfaces of the human lobe may show a variable degree of fusion with the middle and the lower lobes. The two corresponding surfaces of the apical lobe of dog are separated by the sharp interfissural crest. The interfissural crest in Brock's figure is shown as a rounded ridge, but in a

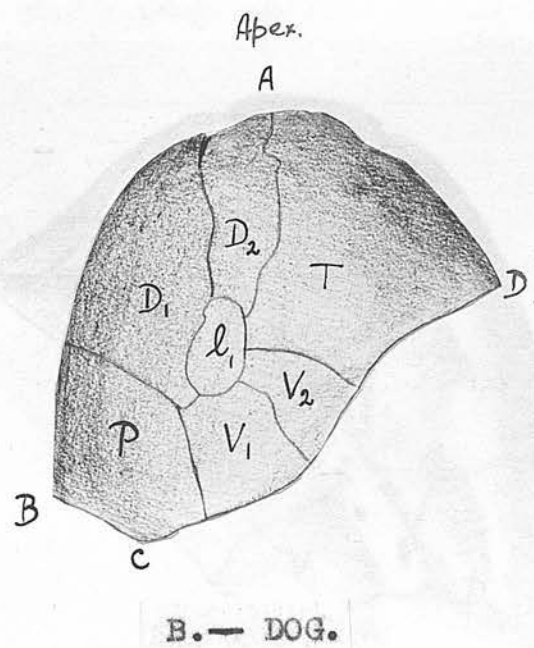
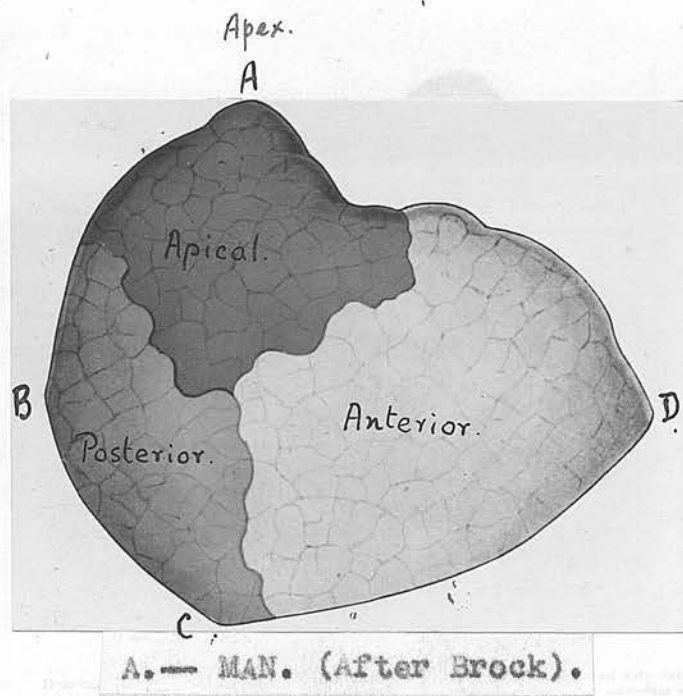


Fig. 52 A & B. Comparison of the Broncho-pulmonary Segments of the Right Upper Lobe of Human, and Right Apical Lobe of Dog's Lung, from the lateral aspect.

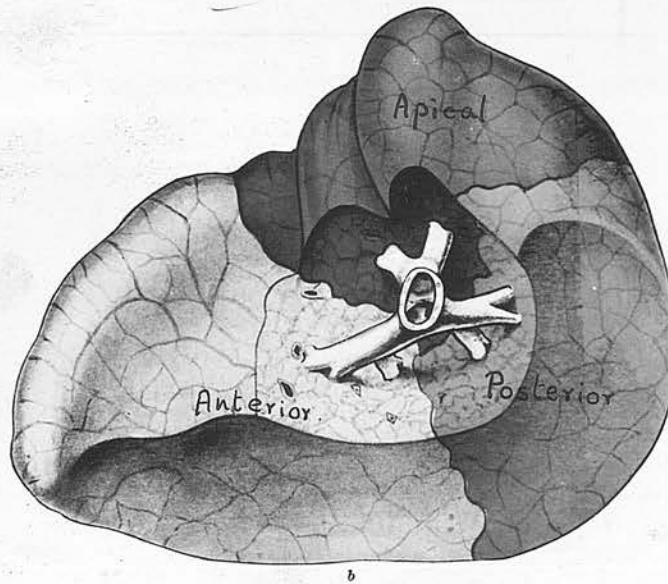
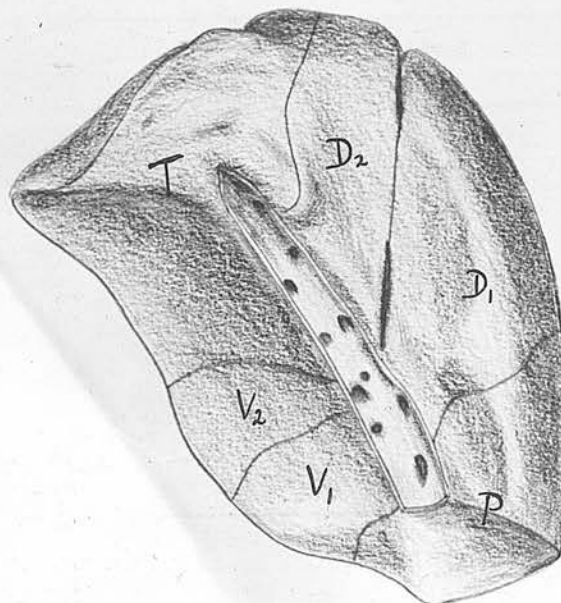


FIG. 18.
Drawings of the right upper lobe in which the individual bronchi were injected with coloured gelatin to show the areas of distribution. The apical segment is in blue, the subapical in red and the pectoral in green.

A.— MAN. (After Brock).



B.— DOG.

Fig. 53 A & B. Comparison of the Broncho-pulmonary Segments of the Right Upper Lobe of Human, and Right Apical Lobe of Dog's Lung, from the medial aspect.

human lobe, hardened in situ, it is usually well defined.

The position of the mediastinal crests in the two lobes are not strictly identical. In the human lobe it is situated between the fissural surface for the middle lobe and the cardiac impression (part of the mediastinal surface), whereas in the dog it is situated between the cardiac surface and the remaining mediastinal surface.

The positions of the apex of the lung and the corresponding borders which have been marked may be noted in the illustrations.

The borders can be compared by studying Figs. 52A, 52B.

The Broncho-Pulmonary Segments

The right human upper lobe comprises three segments, the posterior, the apical and the anterior, whereas the corresponding lobe of the dog's lung has been divided into six segments, P, D₁, D₂, V₁, V₂ and T.

The Posterior Segment

The posterior segment is projected on the costal surface, the whole of the fissural surface for the lower lobe, a part of the fissural surface for the middle lobe and the medial surface in the paravertebral region. The corresponding segment in the dog is the P-segment, which is projected on the corresponding surfaces, and has, therefore, similar topographical relationships. Each bears the interfissural crest.

In these illustrations, however, the P-segment of the dog can be seen to extend more along the dorsal border than does the posterior segment of the human lung. This is obviously associated with a greater obliquity of the oblique fissure in man. The posterior segment, therefore, appears to be compressed from the fissural aspect.

The Apical Segment

The apical segment in the human lung is projected on the costal and the mediastinal surface. Its position on the cephalic aspect of the posterior segment is identical to segment D_1 of the dog's lung, which is projected on corresponding surfaces. Here a notable difference lies in the apical segment forming the apex of the human lung, whereas segment D_1 only tends to reach the apex of dog's lung. The apical segment is roughly quadrilateral in shape, whereas the corresponding segment D_1 possesses a triangular appearance. This difference in the shape of the two segments can be imagined easily to be associated with the "rotation" of the human lung, described already. It appears as if the apical segment corresponding to segment D_1 has been moved bodily to occupy a different position under the apex and thus forms the upper part of the ventral border of the lung. This is associated with a shortening of the dorsal border of the human upper lobe.

The Anterior Segment

The morphological similarity of the posterior and the apical segments of the human lung with segments P and D_1 respectively of the dog's lung having been established, it is obvious that the remaining segments of the apical lobe of dog, viz., segments D_2 , V_1 , V_2 and T, correspond to the anterior segment of the human right apical lobe. These two corresponding territories are related to the corresponding borders and surfaces and each bears the mediastinal crest of the respective lobe.

The corresponding territories of the human upper lobe and dog's apical lobe are shown in Table 32 (item I(1)).

Right Middle Lobe of Human and Right
Cardiac Lobe of Dog's Lung

(Figs. 54A, 54B, 55A, 55B)

The two lobes strongly resemble in shape.

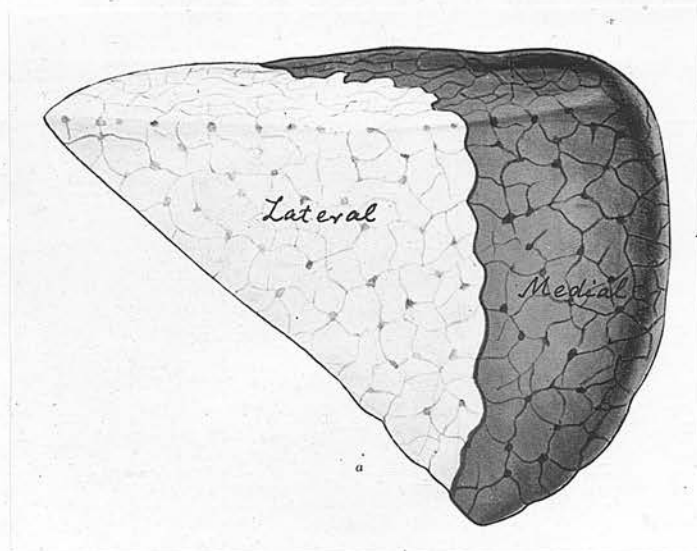
Boyden and Hamre (1951) have described the right middle lobe of the human lung to possess five surfaces to which they have given the following names:-

- (1) The "superior" or "horizontal" surface bordering the horizontal fissure (the "anterior interlobar" surface of Boyden and Hamre, 1949).
- (2) The "mediastinal" surface, contiguous with the pericardium.
- (3) The "oblique" surface, bordering the oblique or interlobar fissure (the "posterior interlobar" surface of Boyden and Hamre, 1949).
- (4) The "diaphragmatic" surface.
- (5) The "costal" surface.

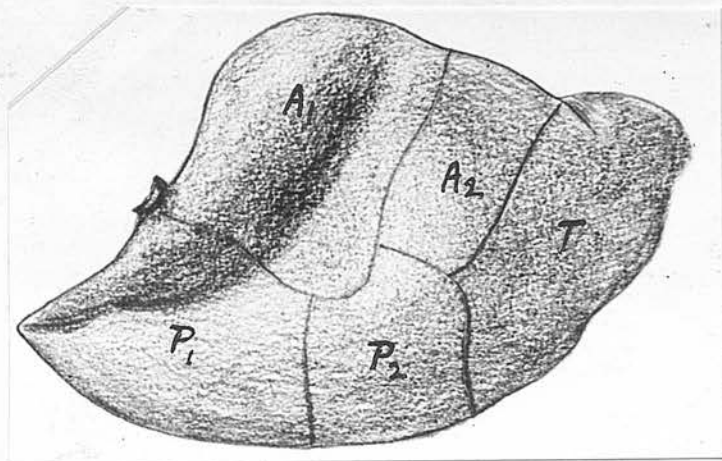
The corresponding surfaces of the dog's lobes enumerated in the same order are:-

- (1) The fissural surface for the apical lobe.
- (2) The mediastinal (or cardiac) surface.
- (3) The fissural surface for the diaphragmatic lobe (the dorsal part of the caudal surface).
- (4) The diaphragmatic surface (the ventral part of the caudal surface).
- (5) The costal surface.

The "frenum" of the human middle lobe (a term used by



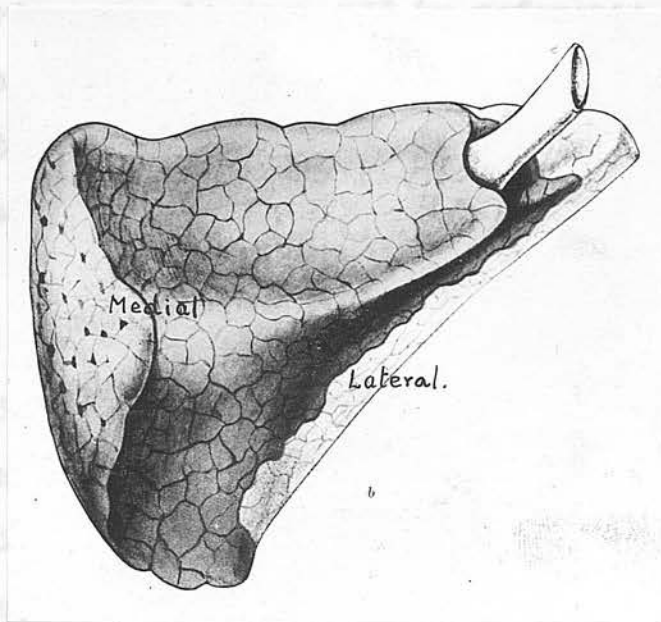
A.— MAN. (After Brock).



B.— DOG.

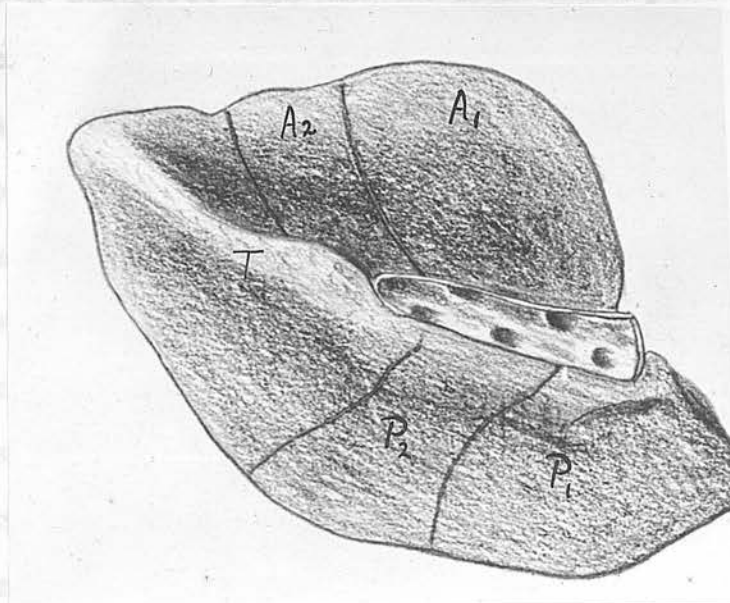
Fig.54 A & B. Comparison of the Broncho-pulmonary Segments of the Right Middle Lobe of Human, and Right Cardiac Lobe of Dog's Lung, from the lateral aspect.

Churchill and Belsey (1939), and adopted by Boyden and Hume), or the "inferior margin" of Smith and Boyden (1949), corresponds to the mediastinal crest of the dog's cardiac lobe. The remaining portion of the human lung corresponds to the lateral margin of the dog's cardiac lobe.



A.— MAN. (After Brock).

The segment of the dog's cardiac lobe, which is projected on corresponding surfaces and has an identical position, is P₁.



B.— DOG.

Fig. 55 A & B. Comparison of the Broncho-pulmonary Segments of the Right Middle Lobe of Human, and Right Cardiac Lobe of Dog's Lung, from the medial aspect.

Churchill and Belsey (1939), and adopted by Boyden and Hamre), or the "inferior margin" of Smith and Boyden (1949), corresponds to the mediastinal crest of the dog's cardiac lobe. The remaining borders may be compared by reference to the illustrations.

The ventral end of the human lobe (the "medial angle" of Boyden and Hamre, 1949) corresponds to the terminal end of the dog's lobe.

The Broncho-Pulmonary Segments

The middle lobe of the right human lung consists of two segments, the lateral and the medial. The cardiac lobe of dog has been divided into five segments, P_1 , P_2 , A_1 , A_2 and T.

The lateral segment of the human lobe is projected on the costal, the superior (or horizontal) and the oblique surfaces. The segment of the dog's cardiac lobe, which is projected on corresponding surfaces and has an identical position, is P_1 . Each of these segments bears the respective interfissural crest.

In the human lobe, the lateral segment can clearly be seen to have expanded laterally, to an extent that it almost equals in size the remaining lobe, i.e., the medial segment, which it overlaps.

(4) The medial segment, it is obvious, corresponds to the remaining segments of the dog's cardiac lobe, viz., P_2 , A_1 , A_2 and T, which form the major part of the dog's lobe. Both these areas bear the ventral ends and the corresponding borders of the lobes, the frenum of the human lobe corresponding to the crest of the dog's lobe.

The corresponding territories of the human middle lobe and the dog's cardiac lobe are shown in Table 32 (item I (2)).

Right Lower Lobe of Human, and Right Diaphragmatic
and Intermediate Lobes of Dog's Lung

(Figs. 56A, 56B, 57A, 57B)

The right lower lobe of human lung, as pointed out already, is equivalent to the diaphragmatic and the intermediate lobes of the right lung of dog. The latter two lobes, therefore, should be compared collectively to the former lobe.

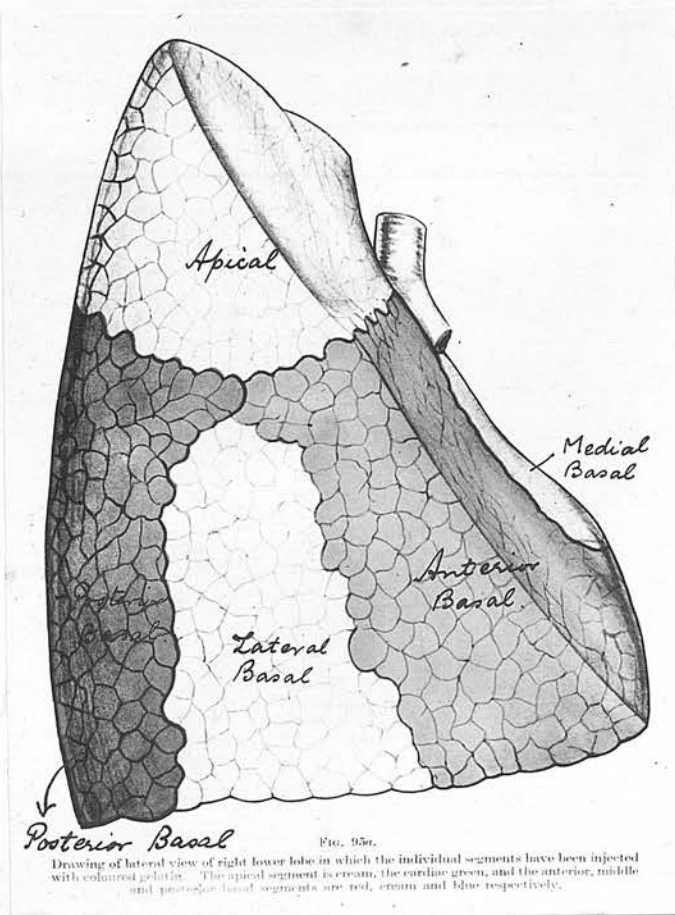
Boyden and Smith (1949) have described the right lower lobe of human lung to possess the following four surfaces:-

- (1) The "anterior" surface.
- (2) The "paravertebral" surface.
- (3) The "costal" surface.
- (4) The "diaphragmatic" surface.

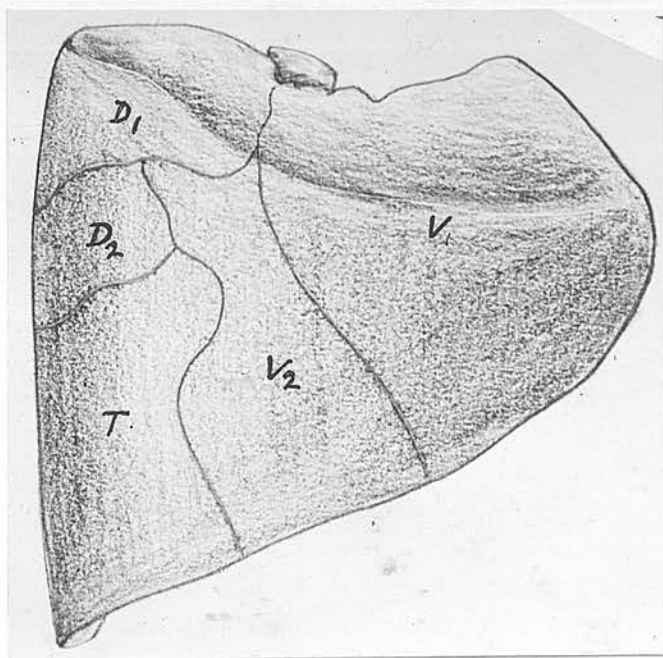
The surfaces of the diaphragmatic lobe of the dog, corresponding to those given above, are:-

- (1) The fissural surface for the apical and the cardiac lobes, disposed in a more ventro-dorsal plane than is the corresponding surface of the human lobe.
- (2) The paravertebral surface - the dorsal part of the medial surface - relatively much narrower in the dog than in man.
- (3) The costal surface - less convex than in the human lobe.
- (4) The diaphragmatic surface, which is formed by the intermediate and the diaphragmatic lobes (compare Fig. 15 with Fig. 58).

The intermediate lobe of dog corresponds, as will be seen later, to the medial basal segment. The latter being a part of the lower lobe of the human lung, the surface corresponding to the fissural surface for the intermediate lobe, a part of the medial surface of the diaphragmatic lobe of dog, is

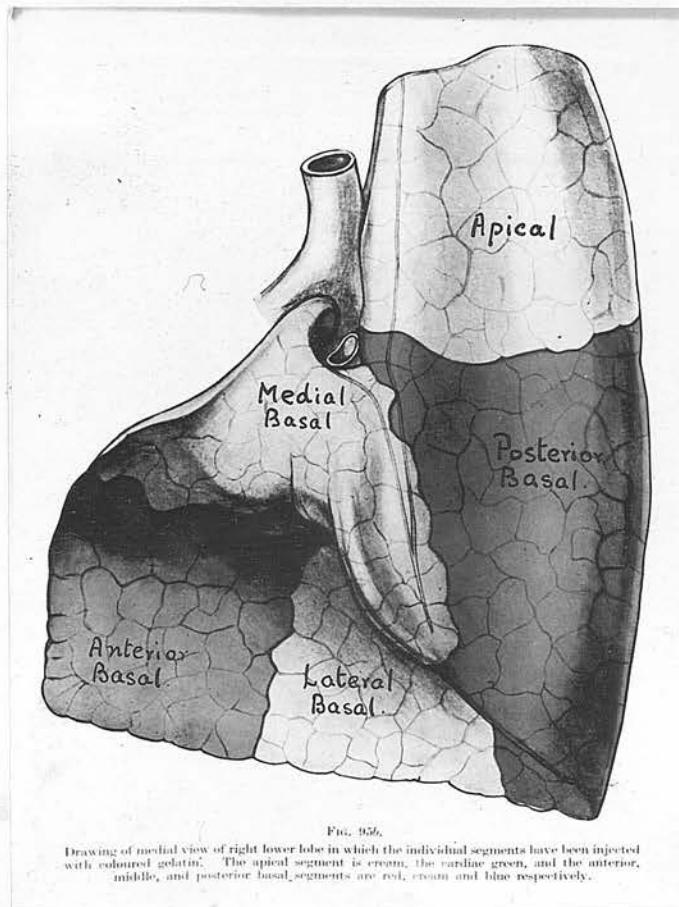


A.— MAN. (After Brock).

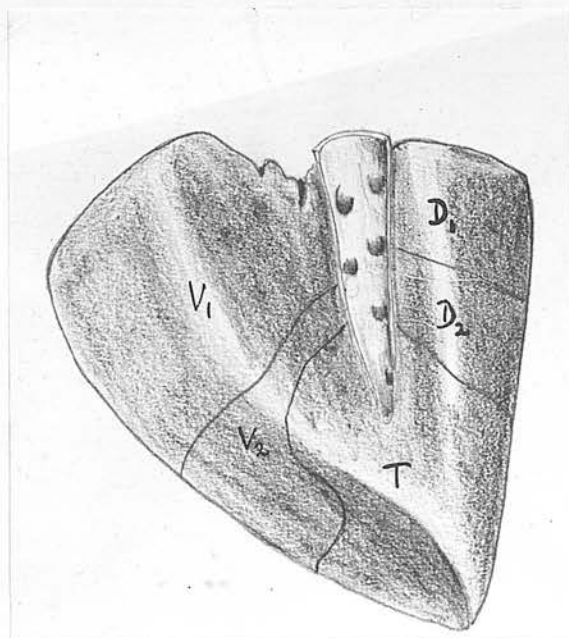


B.— DOG.

Fig. 56 A & B. Comparison of the Broncho-pulmonary Segments of the Right Lower Lobe of Human, and Right Diaphragmatic Lobe of Dog's Lung, from the lateral aspect.



A.— MAN. (After Brock).



B.— DOG.

Fig. 57 A & B. Comparison of the Broncho-pulmonary Segments of the Right Lower Lobe of Human, and Right Diaphragmatic Lobe of Dog's Lung, from the medial aspect.

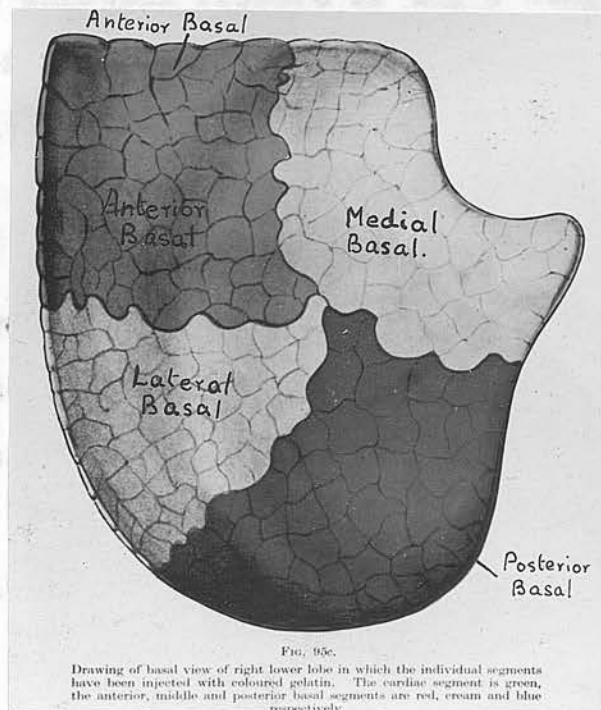


Fig.58 . Broncho-pulmonary Segments of the Right Lower Lobe of Human Lung - Diaphragmatic View. (After Brock)

This segment is projected on the interlobar, the costal and the paravertebral surfaces. Clearly segment D₁ in the dog's lobe occupies an identical position and is projected on corresponding surfaces, the fissural, the costal and the paravertebral. Segment D₁ appears flattened in a cephalo-caudal direction. The apical segment appears expanded not only in the transverse but also in the vertical direction.

The Anterior and the Lateral Basal Segments

The identical positions and surface projections of these two segments and segments V₁ and V₂ in the dog's lobe are clear from the illustrations except that in the human lower lobe the two are fused to the medial basal (cardiac) segment. In the diaphragmatic lobe of the dog they form the lateral boundary of the sagittal fissure. Both are expanded in the

concealed by the fusion of the medial basal segment. The plane of the sagittal fissure of dog's lung, therefore, is represented in the human lung by the plane of fusion of the medial basal segment with the rest of the lower lobe of human lung. (Fig. 58)

The Broncho-Pulmonary Segments

The lower lobe of the human lung is divided into five segments, the apical, the anterior basal, the lateral basal, the posterior basal and the medial basal (cardiac) segment.

Taking the diaphragmatic and the intermediate lobes of dog collectively they have been divided into the following segments:- in the international nomenclature.

Diaphragmatic lobe - Segments D_1 , D_2 , V_1 , V_2 and T.

Intermediate lobe - Segments D_1 , V_1 and T.

The Apical Segment

This segment is projected on the interlobar, the costal and the paravertebral surfaces. Clearly segment D_1 in the dog's lobe occupies an identical position and is projected on corresponding surfaces, the fissural, the costal and the paravertebral. Segment D_1 appears flattened in a cephalico-caudal direction. The apical segment appears expanded not only in the transverse but also in the vertical direction.

The Anterior and the Lateral Basal Segments

The identical positions and surface projections of these two segments and segments V_1 and V_2 in the dog's lobe are clear from the illustrations except that in the human lower lobe the two are fused to the medial basal (cardiac) segment. In the diaphragmatic lobe of the dog they form the lateral boundary of the sagittal fissure. Both are expanded in the

transverse direction as compared to the dog's corresponding segments.

The anterior basal segment in man appears to be compressed, as compared to segment V_1 of dog from the fissural aspect by the middle lobe. This is associated with the greater obliquity of the oblique fissure.

The Posterior Basal Segment

The position of this segment in the human lower lobe can be seen to correspond to the combined position of segments D_2 and T in the dog. Segment D_2 corresponds to the "subapical" segment of Hardie Neil and Gilmour, which has not been recognised in the international nomenclature. These two corresponding territories are projected on identical surfaces and borders.

The Medial Basal (Cardiac) Segment

This segment has "typically roughly pyramidal" shape (Brock). Its position is identical to the position of the intermediate lobe of dog which also is pyramidal. A comparison of their corresponding surfaces is complicated by the relation of the inferior (caudal) vena cava although a rough resemblance can be seen. Each has a diaphragmatic and a cardiac surface - each surface being more extensive in the intermediate^{lobe}. The lateral surface of the segment is applied to the three basal segments, whereas the intermediate lobe is related to the sagittal fissure with the vena cava intervening. The segment in the human lung has a narrow interlobar surface, bordering the oblique fissure. This is absent in the intermediate lobe.

Comparing their size, the intermediate lobe is relatively

much bigger of the two.

Thus it is clear that the general plan of segments is similar, but the following differences exist:-

(1) The intermediate lobe in the dog is represented by the medial basal segment, the former separated by the sagittal fissure. The intermediate lobe is divided into three segments, D_1 , V_1 and T.

(2) There is an additional dorsal segment D_2 in dog which corresponds to the "subapical" segment of Hardie Neil and Gilmour.

The corresponding territories are represented in Table 32 (item I (3)).

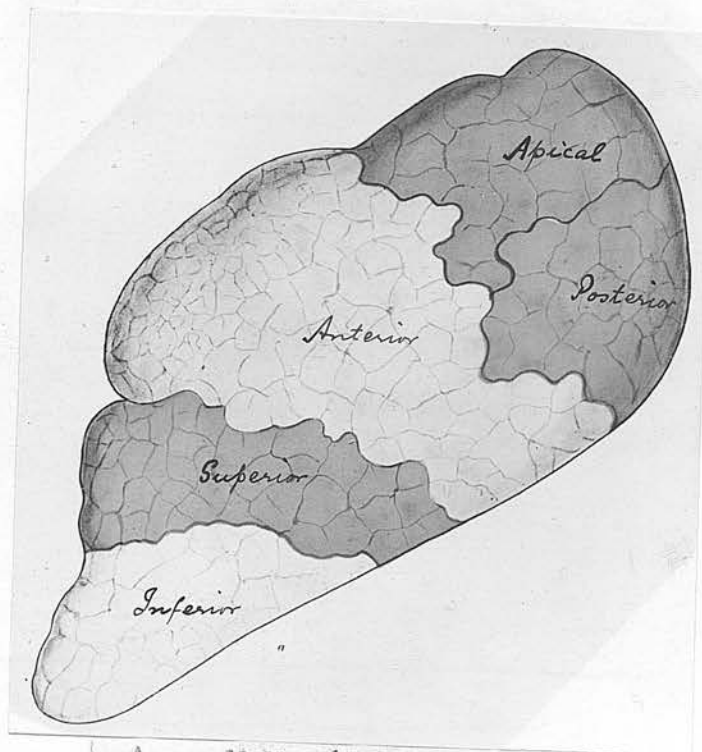
Left Upper Lobe of Human, and the Left
Apical and Cardiac Lobes of the Dog's Lung

(Figs. 59A , 59B , 60A , 60B)

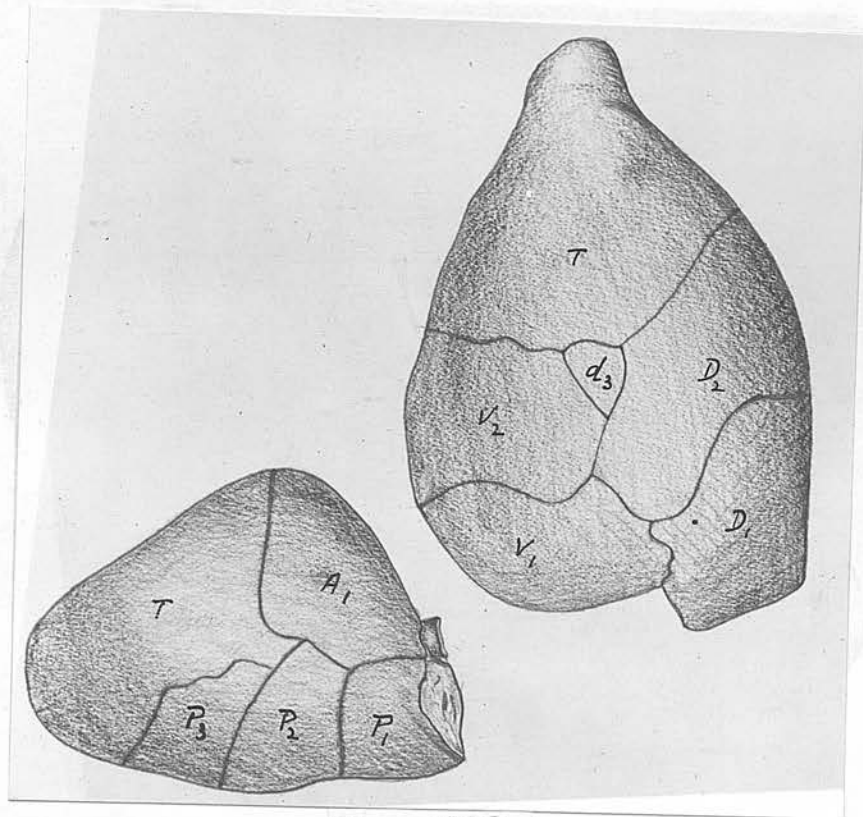
The correspondence of the upper part of the left upper lobe and the lingula of the human lung with the left apical and the cardiac lobes respectively, has already been pointed out.

Each of these two corresponding parts possesses a costal, a medial and a fissural surface for the diaphragmatic lobe. The resemblance between the two, however, is much less marked than between the other lobes. However, if the lingula be separated by a deep fissure from the rest of the lobe, its resemblance to the left cardiac lobe of dog ^{would} become marked. Such a human lung has been illustrated by Churchill and Belsey (1939) in their Fig. 1.

The apical and the cardiac lobes in the dog's lung, are

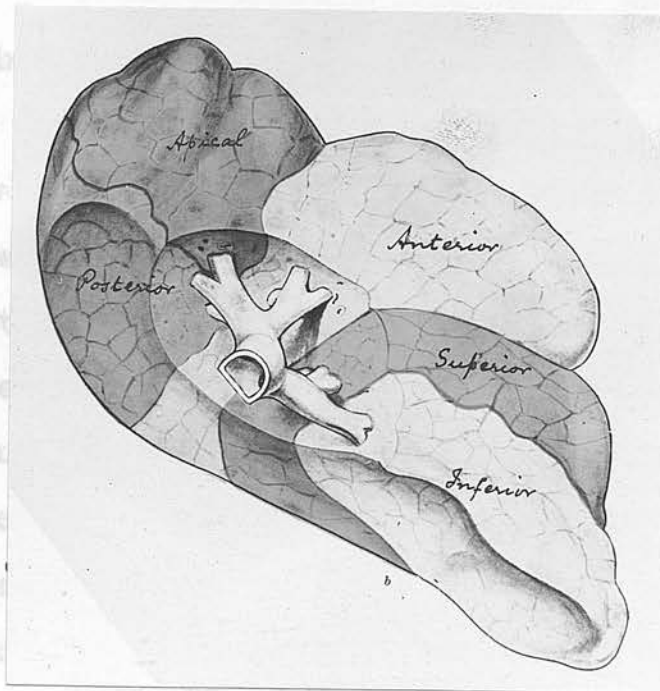


A.— MAN. (After Brock).

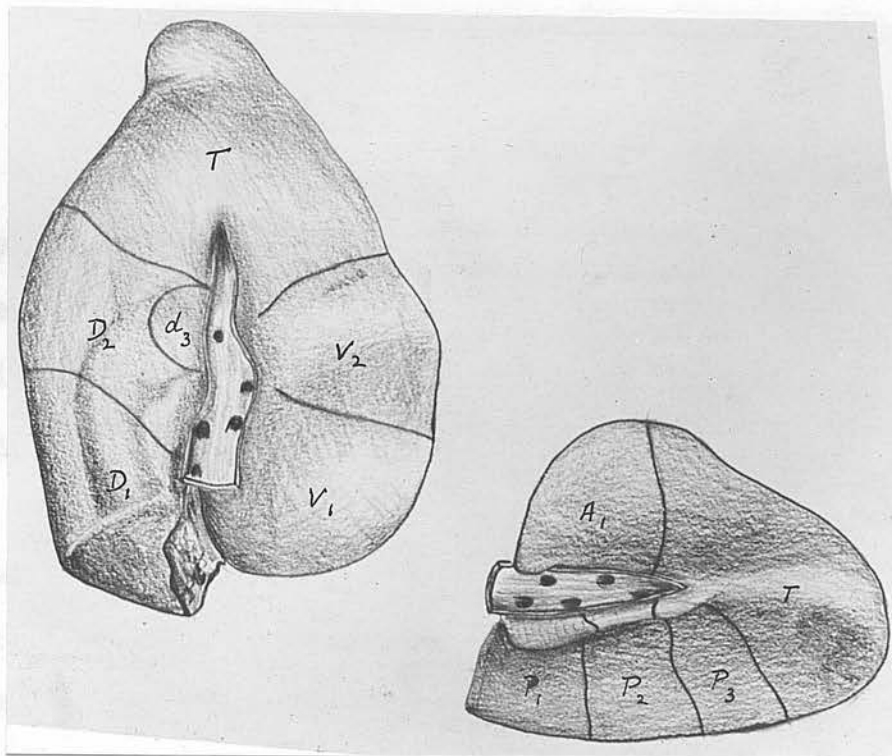


B.— DOG.

Fig. 59 A & B. Comparison of the Broncho-pulmonary Segments of the Left Upper Lobe of the Human, and Left Apical and Cardiac Lobes of Dog's Lung, from the lateral aspect.



A.— MAN. (After Brock).



B.— DOG.

Fig. 60 A & B. Comparison of the Broncho-pulmonary Segments of the Left Upper Lobe of Human, and Left Apical and Cardiac Lobes of Dog's Lung, from the medial aspect.

separated by the minor fissure; no corresponding fissure is present in the human left upper lobe, it being represented in Fig. 59a by an indent only.

The left apical lobe of the dog's lung has its long axis directed cephalically with the apex pointed and well marked, whereas the corresponding area of the human lung has its long axis directed ventrally and slightly caudally.

The long axis of the left cardiac lobe of the dog is directed ventrally and caudally; the axis of the lingula is directed more caudally than the dog's cardiac lobe. Each possesses an identical ventral end.

The dorsal border of the left apical lobe is relatively much longer than the corresponding border of the human lung.

The Broncho-Pulmonary Segments of the Upper
Part of Left Upper Lobe of Human and Left
Apical Lobe of Dog's Lung

The upper part of the left upper lobe of human lung comprises three segments, the posterior, the apical and the anterior. The left apical lobe of dog's lung has been divided into segments D_1 , D_2 , D_3 , V_1 , V_2 and T.

Posterior Segment

The posterior segment is projected on the costal, the fissural and a small part of the paravertebral surface. It can be clearly seen that segment D_1 of the left apical lobe possesses the same surface relations, but in the dog segment D_1 is fused to segment P_1 of the cardiac lobe, whereas the posterior segment of the human lung is separated from the lingula by a thick mass of lung tissue belonging to the anterior segment.

The Apical and the Anterior Segments

It is difficult to compare these two segments with the segments of the dog's lung. Two alternative interpretations are possible:-

I. In the human lung, cephalic to the posterior segment, lies the apical segment. The position corresponding to the apical segment is occupied, in the dog, by segment D_2 . Both the apical and the D_2 segments possess costal and medial surfaces.

The apical segment of the left upper lobe forms the apex of the lung as does the apical segment of the right upper lobe. On the analogy of the latter, the former, corresponding to segment D_2 of dog's left apical lobe, may be considered to have taken up a position under the apex of the lung as a result of the "rotation" of the lung already described.

If the above explanation be accepted then the anterior segment corresponds to the remaining part of the dog's apical lobe, i.e., the area formed by segments D_3 , V_1 , V_2 and T. (Table 32, item II (1)(a))

II. The posterior segment is related ventrally to the anterior segment. Segment D_1 , corresponding to the posterior segment, is related ventrally to segment V_1 . The anterior segment in man may be imagined to be an enlarged segment V_1 , so that the apical segment is then equivalent to the area formed by segments V_2 , D_2 , D_3 and T. (Table 32, item II (1) (b))

Thus the existence of these alternative interpretations makes it difficult to determine any morphological homology between the apical and the anterior segments of the human left upper lobe

and the segments of the left apical lobe of dog.

The Broncho-Pulmonary Segments of the Lingula of Human,
and the Left Cardiac Lobe of Dog's Lung

The lingula is divided into two segments, the superior and the inferior. The left cardiac lobe of dog has been divided into five segments, P_1 , P_2 , P_3 , A_1 and T.

The superior segment is projected on the costal, mediastinal and fissural surfaces. Its ventral part, in its position, resembles segment A_1 and its dorsal part to segment P_1 of the cardiac lobe. Either of these two segments of the dog can be considered to have overgrown in the human lung to an extent that it intervenes between the anterior and the inferior segments.

Thus, here too, comparison is made difficult due to two alternative explanations, according to whether the superior segment is considered to be morphologically identical to segment P_1 or A_1 of the dog:-

- I. If the superior segment be considered homologous to segment P_1 , the inferior segment would be equivalent to segments P_2 , P_3 , A_1 and T (Table 32 , item II, (2)(a)).
- II. If the superior segment be considered homologous to segment A_1 , then the inferior segment would be equivalent to segments P_1 , P_2 , P_3 and T. (Table 32 , item II, (2)(b)).

However, it can be seen that a complete morphological resemblance between the superior segment and its possible homologue, either segment A_1 or segment P_1 , does not exist.

The Apical Segment

This segment is projected on the anterior, costal and

Left Lower Lobe of Human and Left
Diaphragmatic Lobe of Dog's Lung

(Figs. 61A , 61B , 62A , 62B)

Berg, Boyden and Smith (1949) have described the left lower lobe of the human lung to possess four surfaces:-

- (1) The "anterior" surface.
- (2) The "costal" surface.
- (3) The "paravertebral" surface.
- (4) The "diaphragmatic" surface.

A fifth surface, called the "cardiac area" in Fig. has been described by them as part of the anterior surface. The corresponding area in the dog's lung (Fig. 17) is distinctly a part of the mediastinal surface.

The diaphragmatic lobe of dog possesses identical surfaces. Given in the same order they are:-

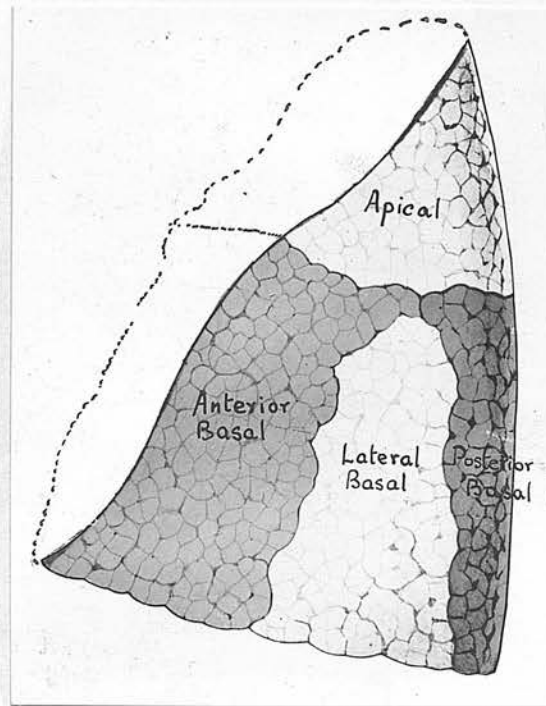
- (1) The fissural surface.
- (2) The costal surface.
- (3) The paravertebral surface.
- (4) The diaphragmatic surface.
- (5) The mediastinal surface which in the lower lobe of human lung is relatively small and represented by the cardiac surface only.

The Broncho-Pulmonary Segments

The left lower lobe of human lung is divided into four segments, the apical, the anterior basal, the middle basal and the posterior basal. The dog's left diaphragmatic lobe has been divided into six segments, D₁, D₂, D₃, V₁, V₂ and T.

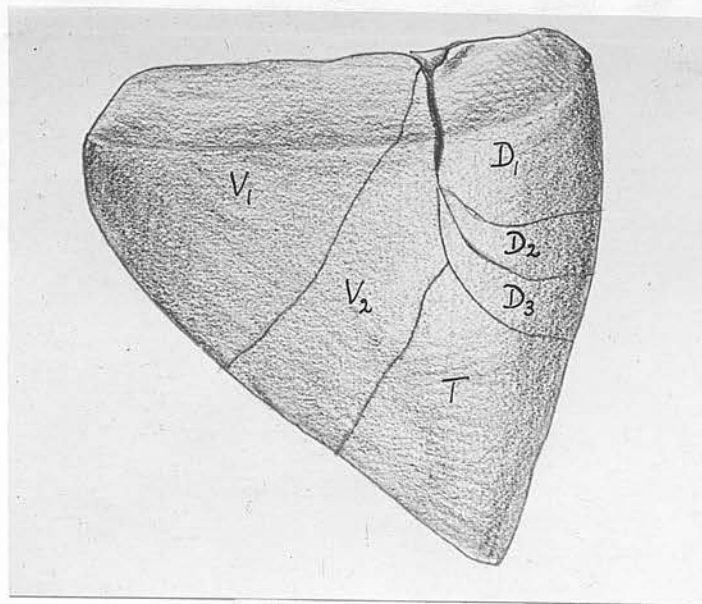
The Apical Segment

This segment is projected on the anterior, costal and



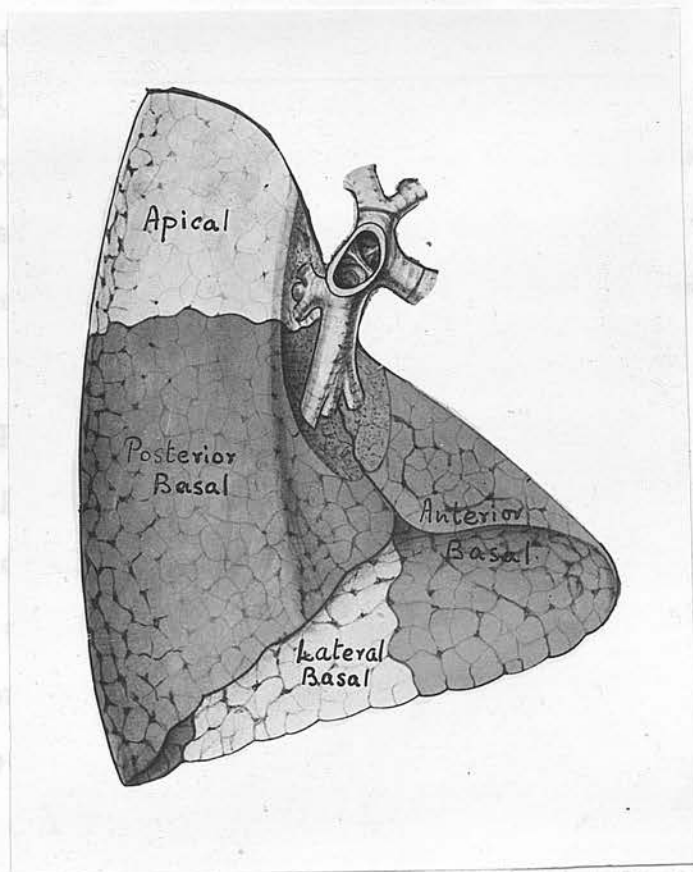
A.— MAN. (After Brock. Derived from his Fig. 123a).

Dotted line added to show interlobar surface projection of segments.

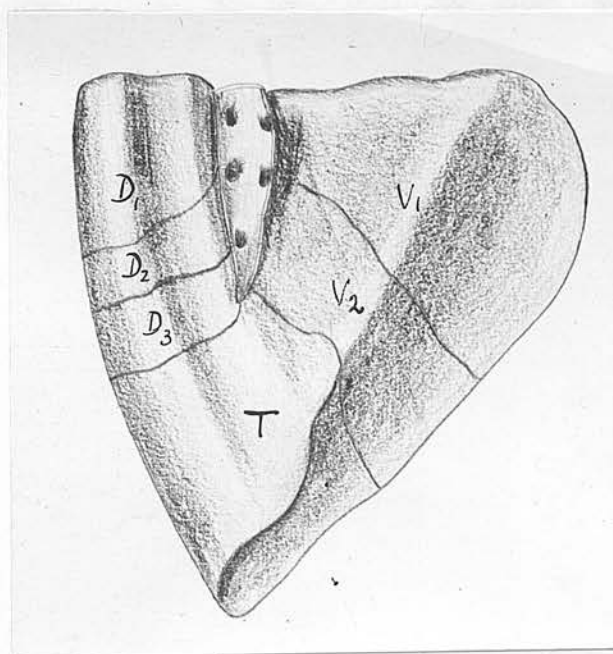


B.— DOG.

Fig. 61 A & B. Comparison of the Broncho-pulmonary Segments of the Left Lower Lobe of Human, and Left Diaphragmatic Lobe of Dog's Lung, from the lateral aspect.



A.— MAN. (After Brock. Derived from his Fig. I23b).



B.— DOG.

Fig. 62. A & B. Comparison of the Broncho-pulmonary Segments of the Left Lower Lobe of Human, and Left Diaphragmatic Lobe of Dog's Lung, from the medial aspect.

paravertebral surfaces, and exactly corresponds to segment D_1 of the diaphragmatic lobe of the dog.

The Anterior and the Lateral Basal Segments

Their position, as on the right side, corresponds exactly to the position of segments V_1 and V_2 of the dog except that in the specimen illustrated in Fig. 33A, segment V_2 extends on to the fissural surface.

The Posterior Basal Segment

The position of this segment in the human lobe can be seen to correspond to the combined position of segments D_2 , D_3 and T of the dog's lobe. The position of segments D_2 and D_3 corresponds to the "subapical" segment of Hardie Neil and Gilmour.

The corresponding territories are represented in Table 32 (item II (3)).

Table 32

MORPHOLOGICALLY HOMOLOGOUS AREAS OF THE LUNGS OF DOG AND OF MAN

	<u>DOG</u>	<u>MAN</u>
I.	<u>R I G H T L U N G</u>	<u>R I G H T L U N G</u>
(1)	<u>Apical Lobe</u>	<u>Upper Lobe</u>
(i)	Segment P	Segment Posterior
(ii)	Segment D ₁	Segment Apical
(iii)	Segments D ₂ +V ₁ +V ₂ +T	Segment Anterior
(2)	<u>Cardiac Lobe</u>	<u>Middle Lobe</u>
(i)	Segment P ₁	Segment Lateral
(ii)	Segments P ₂ +A ₁ +A ₂ +T	Segment Medial
(3)	<u>Diaphragmatic Lobe and Intermediate Lobe</u>	<u>Lower Lobe</u>
	<u>Diaphragmatic Lobe</u>	<u>Segments Anterior Basal + Lateral Basal + Posterior Basal</u>
(i)	Segment D ₁	Segment Apical
(ii)	Segment V ₁	Segment Anterior Basal
(iii)	Segment V ₂	Segment Lateral Basal
(iv)	Segments D ₂ +T	Segment Posterior Basal
(v)	<u>Intermediate Lobe</u>	<u>Segment Medial Basal</u>
	Segments D ₁ +V ₁ +T	-

COMPARISON OF THE GENERATIONS OF BRONCHI

Table 32 contd.

II.	DOG		MAN	
	LEFT LUNG		LEFT LUNG	
(1)			<u>Upper Lobe (Upper Division)</u>	
			Segment Posterior	
			Segment Apical	
			Segment Anterior	
(2)			<u>Upper Lobe (Lingula)</u>	
			Segment Superior	
			Segment Inferior	
			<u>Lower Lobe</u>	
(3)			Segment Apical	
			Segment Anterior Basal	
			Segment Lateral Basal	
			Segment Posterior Basal	
(1)			<u>Alternative Interpretation</u>	
			Segment Posterior	
			Segment Anterior	
			Segment Apical	
(2)			<u>Alternative Interpretation</u>	
			Segment Superior	
			Segment Inferior	
			<u>Lower Lobe</u>	
(3)			Segment Apical	
			Segment Anterior Basal	
			Segment Lateral Basal	
			Segment Posterior Basal	

COMPARISON OF THE GENERATIONS OF BRONCHI

A morphological comparison having been made, it is now necessary to work out and compare the generations of the bronchi, supplying the identical areas of the lungs of dog and of man, before the presence or absence of absolute homology between them can be declared.

On the left side the existence of alternative interpretations between areas indicated under items II (1) and II (2) in Table 32 make a morphological identification between these areas difficult. Segment D_1 , however, is an exception which maintains its correspondence to the posterior segment under either interpretation.

The generations of bronchi of dog's lungs were worked out from Charts I , II , III , IV , V , VI and VII.

When two branches originate from the parent bronchus at the same level, it is difficult to interpret their generations. Just as either of the two branches on the lobar stem bronchus, in such a case, was presumed to hold alternative numerical positions (see page 109), similarly each of these branches has been presumed to belong to two alternative generations; and their generations will be expressed as such.

The generations of bronchi of the human lung were determined on 5 corrosion preparations. Literature does not provide any ready data on the generations of human bronchi. However, the accounts given by various authors were carefully studied. It was found that not all the patterns given by various investigators could be deciphered in terms of generations. The accounts of Ewart, Brock, and Boyden and co-authors, which

are very detailed, were found most useful for this purpose. The results of analyses of bronchial patterns given by Boyden and co-authors are so exhaustive, and the variation patterns so numerous, that a consideration of each one of them for comparison is impracticable; nor was it possible to determine the generations of bronchi in each of the patterns described. Those patterns, however, in which the generations could be interpreted with absolute certainty, have been interpreted for comparison.

The generations were also determined by studying Aeby's Fig. 7, depicting his pattern of human bronchial tree (Fig. 63).

All generations worked out have been recorded in Tables 33 , 34 , 35 , 36 , 37 and 38 . From these Tables the generations of individual bronchi were analysed.

The comparison of the generations of bronchi supplying morphologically identical areas of the lungs of dog and of man has been done in Tables 39 and 40 .

Summary and Conclusions

The data presented are inadequate for a statistical comparison. But it is possible to point out examples of complete or partial homology in the material studied. It may be emphasised that the conclusions given below are only applicable to the material studied and the instances cited from the literature in column 3 of Tables 39 and 40 .

(5) Some general observations may, however, be noted first:-

(1) An area* may be supplied by a bronchus of the same genera-

*The term "area" is used in reference to the areas shown in Table 32.

- tion in all specimens of the same animal. (Example: Segment P of right apical lobe of dog; Table 39).
- (2) Two corresponding areas in the lungs of dog and of man may be supplied by bronchi belonging to the same generation in all specimens. (Example: Segment D_1 of the left diaphragmatic lobe of dog, and the apical segment of left lower lobe of man; Table 40).
- (3) The corresponding areas in the lungs of dog and of man may be supplied by bronchi of entirely different generations in all the specimens. (Example: Segment D_1 of the left apical lobe in dog, and the posterior segment of left upper lobe in man; Table 40).
- (4) The corresponding areas in the lungs of dog and of man may be supplied by the bronchi of the same generation only in some of the specimens. (Example: Segment V_2 of the right diaphragmatic lobe in dog, and the lateral basal segment of right lower lobe in man; Table 39).
- (5) In some specimens the generation of a bronchus may be doubtful. (Example: Segment V_2 of right diaphragmatic lobe in dog, in which, in one lobe, the generation is 7th or 8th, in two lobes 8th or 9th, and in one 10th or 11th; Table 39). It is interesting to note that such instances in the human lung are few and restricted to right upper lobe only, as far as the data given in Tables 39^{and 40} are concerned.
- (6) In some specimens an area may be supplied by more than one bronchus, each belonging to a different generation. (Example: Area D_2+T in right diaphragmatic lobe of the dog; Table 39).
- Examples of absolute and partial homologies can easily be picked out from these Tables. If the instances of absolute

homologies be picked out, all remaining instances would conform to partial homologies. Those specimens, in which the corresponding areas of the human and the dog's lungs are supplied by bronchi of the same generations, are indicated in the Tables by the letters A.H. in column 4 (signifying Absolute Homology).

Homology between two areas of the lungs may need to be determined either between the right and the left lungs of the same animal, or between the lungs of the same side in the same or different animals. Accordingly, examples of absolute homology can be classified under the following headings:-

- I. Homologous areas in the right lungs of dogs.
- II. Homologous areas in the left lungs of dogs.
- III. Homologous areas in the right human lungs.
- IV. Homologous areas in the left human lungs.
- V. Homologous areas between the right dog's and the right human lung.
- VI. Homologous areas between the left dog's and the left human lung.
- VII. Homologous areas between the right and the left lungs of dog.
- VIII. Homologous areas between the right and the left lungs of man.

The homologies between the right and the left lungs of dog and of man (VII and VIII) are deferred for later discussion (page 396).

Examples of lobes and of broncho-pulmonary segments which exhibit perfect homology, according to the above classification, are enumerated below. The generations of their bronchi are placed in parenthesis.

I. Homologous Areas in the Right Lungs of Dogs (Table 39)

1. All apical lobes (2)
2. P segments of all apical lobes (3)
3. All cardiac lobes (3)
4. All diaphragmatic and the intermediate lobes, the two considered as one unit, and supplied by the stem bronchus (3). The two lobes considered individually are partially homologous in some, and perfectly homologous in other specimens.

The generation of bronchus D_1 is doubtful (4th or 5th) in 4 out of 37 specimens; in the remaining 33 specimens the generation is 4th. This is an example in which segment D_1 may be considered almost perfectly homologous in all specimens. Same remarks apply to the area composed of segments D_2 , V_1 , V_2 and T in the apical lobe.

II. Homologous Areas in the Left Lungs of Dogs (Table 40)

1. All apical lobes (3)
2. Segment D_1 of all apical lobes (4)
3. All cardiac lobes (3)
4. Segment P_1 of all cardiac lobes (4)
5. All diaphragmatic lobes (2)
6. Segment D_1 of all diaphragmatic lobes (3)
7. Segment V_1 of all diaphragmatic lobes (4)

III. Homologous Areas in the Right Human Lungs (Table 39)

1. All upper lobes (2)
2. All middle lobes (3)
- 4.
3. The lateral segment of all middle lobes/except in the following two atypical patterns of Boyden and Hamre:-

(i) "Modified lateral-medial pattern" - Table 34,
item V (b)

(ii) "Superior-inferior pattern" - Table 34, item V (c).

4. The medial segment of all middle lobes (4) except in Boyden and Hamre's "Superior-inferior" pattern - Table 34, item V (c).

5. All lower lobes (3).

6. The apical segment of all lower lobes (4).

7. The medial basal segment of all lower lobes (5).

IV. Homologous Areas in the Left Human Lungs (Table 40)

1. All upper lobe - upper divisions (3).

2. The anterior segment of all upper lobes (4).

3. All upper lobe - lower (lingular) divisions (3).

4. All lower lobes (2).

5. The apical segments of all lower lobes (3).

V. and VI. Homologous Areas Between the Respective Right and Left Lungs of Dog and of Man (Tables 39, 40)

All examples of absolute homologies between the dog's and human lungs, as pointed out before, are indicated by the letters A.H. in the Tables.

The areas, which have been found to be constantly homologous in all the specimens studied and in all the examples cited from literature, are given below:-

(1) Right apical lobe in dog and right upper lobe in man (2).

(2) Right cardiac lobe in dog and right middle lobe in man (3).

(3) Right diaphragmatic and intermediate lobes, taken together, in dog, and right lower lobe in man (3).

(4) Left apical lobe in dog and left upper lobe - upper division in man (3).

(5) Left cardiac lobe in dog and left upper lobe - lower division (lingula) in man (3).

(6) Left diaphragmatic lobe in dog and left lower lobe in man (2).

(7) Segment D₁ of left diaphragmatic lobe of dog and apical segment of left lower lobe in man (3).

The conclusion from this is that constant absolute homology between the human and dog's lungs exists only up to the lobar level when the right diaphragmatic and the intermediate lobes be taken as one lobar unit. The only instance of constant absolute homology at segmental level is between segment D₁ of left diaphragmatic lobe of dog and apical segment of left lower lobe of human lung.

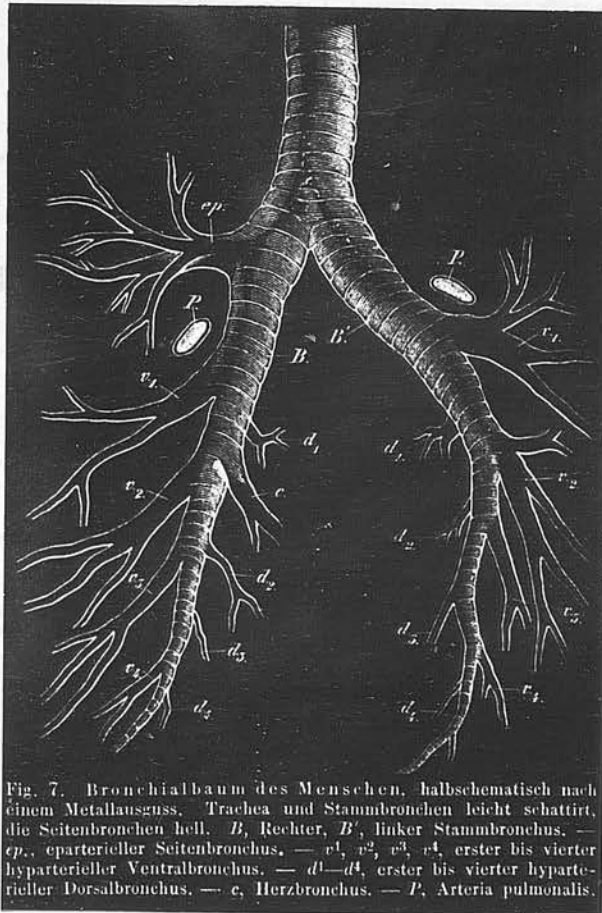


Fig. 7. Bronchialbaum des Menschen, halbschematisch nach einem Metallausguss. Trachea und Stammbronchen leicht schattirt, die Seitenbronchen hell. *B*, Rechter, *B'*, linker Stammbronchus. — *ep.*, eparterieller Seitenbronchus. — *v*¹, *v*², *v*³, *v*⁴, erster bis vierter hyparterieller Ventralbronchus. — *d*¹—*d*⁴, erster bis vierter hyparterieller Dorsalbronchus. — *c*, Herzbronchus. — *P*, Arteria pulmonalis.

Fig. 63. Aeby's Fig. 7

Table 34. THE GENERATIONS OF THE LOBAR AND SEGMENTAL BRONCHI OF RIGHT MIDDLE LOBE OF HUMAN LUNG
(Writer's own findings in 5 bronchial casts and the generations determined by studying the accounts given by some other authors).

AUTHOR	PATTERN AND/OR SPECIMEN NOS.	GENERATIONS		
		BRONCHUS (International Nomenclature)		
		Middle Lobe Bronchus	Segmental Bronchi	
			Lateral	Medial
I Writer's Own Findings	Lobar stem bifurcates in all 5 specimens	3	4	4
II Aeby (1880)	The pattern depicted in his Fig. 7.	"V ₁ " 3	Unnamed 4	Unnamed 4
III Ewart (1889)	The Lobar bronchus divides into "Superficial mammary cardiac" and "Inner" or "sterno-cardiac trunks"	The "cardiac" or "middle lobar bronchus" 3	"Outer" or "Super- ficial mammary trunk" 4	"Inner" or "Sterno- cardiac trunk" 4
IV Brock (1946)	Lobar bronchus divides into 2 branches	3	"Lateral" 4	"Medial" or "Anterior" 4
V Boyden and Hamre (1951)	(a) "Prevailing lateral-medial" pattern	3	"B ₄ " 4	"B ₅ " 4
	(b) "Modified lateral medial" pattern. Branches of bronchus B ₄ , i.e., B _{4a} and B _{4b} have different origins. B _{4a} origin- ates from stem of lobar bronchus; B _{4b} originates from B ₅ .	3	"B _{4a} " - 4 "B _{4b} " - 5	"B ₅ " 4
	(c) "Superior-inferior" pattern (See foot-note)	3	4 (See Foot-note)	4 (See Foot-note)

Foot-note : With regard to this pattern Boyden and Hamre state that it "seems to be due both to a displacement and to a rotation of bronchi on the lobar stem". It is not possible to say which way rotation has taken place and it is therefore difficult to interpret which of the two bronchi should be considered as B₄ or B₅. Each, however, would be a 4th generation bronchus.

Table 35

THE GENERATIONS OF LOBAR AND SEGMENTAL BRONCHI OF THE RIGHT LOWER LOBE OF HUMAN LUNG
(Writer's own findings in 5 bronchial casts and the generations determined by
studying the accounts given by some other authors)

AUTHOR	PATTERN AND/OR SPECIMEN NOS.	GENERATIONS						
		BRONCHUS (International Nomenclature)						"Subapical Bronchus" (Neil et al., 1938)
		Lower Lobe	Segmental Bronchi					
	Apical		Medial Basal (Cardiac)	Anterior Basal	Lateral Basal	Posterior Basal		
I. Writer's own find- ings	(a) Specimens 1, 2, 4.	3	4	5	6	7	7	8
	(b) Specimen 3	3	4	5	8	8	6	7
	(c) Specimen 5	3	4	5	7	7	6	7
II. Aeby (1880)	The pattern depicted in his Fig. 7.	The "Stem bronchus"	"d ₁ "	"Cardiac bronchus"	"V ₂ "	"V ₃ "	"Stem bron- chus with d ₃ , d ₄ and v ₃ "	"d ₂ "
		3	4	5	6	8	8	7
III. Ewart (1889)	Only a single pattern described	3	"Posterior Horizontal"	"Retro- cardiac"	"Anterior basic"	"Axillary basic"	"Posterior basic"	"Lesser Posterior Horizontal" 7
IV. Brock (1946)	(a) When "Subapical" bronchus of lower lobe arises below the cardiac bronchus	3	"Apical"	"Cardiac"	"Anterior Basal"	"Middle Basal"	"Posterior Basal"	"Subapical"
			4	5	7	8	8	6
	(b) When "Subapical" bronchus is absent	3	4	5	6	7	7	absent
	(c) When "Subapical" bronchus is a branch of posterior basal bronchus	3	4	5	6	7	7	8
V. Smith and Boyden (1949)	(a) According to their Table III, Item II.1.(1)(a) Bronchus B* arises from the common stem of bronchi B ₈ , B ₉ and B ₁₀ .	3	"B ₆ "	"B ₇ "	"B ₈ "	"B ₉ "	"B ₁₀ "	"Sub- superior "B*" or "BX*" (See footnote)
			4	5	7	8	8	B* - 6
	(b) According to their Table III, Item II.1.(1)(b), Bronchus B* arises from the common stem of bronchi B ₉ and B ₁₀ .	3	4	5	6	8	8	B* - 7
	(c) According to their Table III, Item II.1(2), bronchus BX* arises from bronchus B ₁₀ .	3	4	5	6	7	7	BX* - 8
	(d) According to their Table III, Item II.2(2), bronchus BX* represented by two bronchi, each a branch of bronchus B ₁₀ .	3	4	5	6	7	7	BX* (2 bronchi) - 8 & 9
	(e) According to their Table III, Item II. 3 (1), bronchus B* represented by two bronchi each arising from the main lobar stem; bronchus BX* arising from bronchus B ₁₀ .	3	4	5	7	9	9	B* (2 bronchi) - 6 & 8 BX* - 10
	(f) According to their Table III, Item II, 4, bronchus B* represented by two bronchi, each arising from the main lobar stem; bronchus BX* also re- presented by two bronchi, each arising from bronchus B ₁₀ .	3	4	5	7	9	9	B* (2 bronchi) - 6 & 8 BX* (2 bronchi - 10 & 11

Footnote:—

The "subapical" bronchi of Neil and Gilmour correspond to the "subsuperior" bronchi described by Smith and Boyden (1949) and Berg, Boyden and Smith (1949). The latter (Boyden and co-authors) have classified the subsuperior bronchi into "subsuperior proper" designated "B*", and "accessory subsuperior" designated "BX*", depending upon whether they originate from the main stem of the lower lobe bronchus or from the posterior basal bronchus (their segmental bronchus "B₁₀") respectively. They have described different number of bronchi B* and BX* in different patterns. The types of subsuperior bronchi are indicated in the last column of the table along with their generations.

Table 36

THE GENERATIONS OF THE LEFT UPPER LOBE-UPPER DIVISION BRONCHUS OF THE HUMAN LUNG AND OF ITS SEGMENTAL BRONCHI
(Writer's own findings in 5 bronchial casts and the generations determined by studying the accounts
given by some other authors)

AUTHOR	PATTERN AND/OR SPECIMEN NOS.	G E N E R A T I O N S					
		BRONCHUS (International Nomenclature)					
		Upper Lobe Bronchus	Upper Division Bronchus	S e g m e n t a l B r o n c h i			
				Apico-Posterior	Apical	Posterior	Anterior
I. Writer's own findings	(a) Specimens 1, 2 and 3. Typical arrangement - the upper division bronchus divides into the anterior segmental and the apico- posterior bronchi	2	3	4	5	5	4
	(b) Specimens 4 and 5. The apico-posterior bronchus gives off a lateral branch before dividing into the apical and the posterior bronchi	2	3	5 (See Footnote)	6	6	4
II. Aeby (1880)	The pattern depicted in his Fig. 7	"V ₁ " 2	Unnamed 3	Unnamed ? 4	Unnamed ? 5	Unnamed ? 5	Unnamed ? 4
III. Ewart (1889)	Only a single pattern described	2	"Pectori-apical stem" 3	"Axillary Apical stem or trunk" 4	"Apical or ascending apical" 5	"Axillary stem" 5	"Pect- oral stem" 4
IV. Brock	The ascending bronchus divides into the pectoral bronchus and the common stem of the apical and the subapical bronchi.	2	"Ascending branch" 3	"Common stem of apical and sub- apical" 4	"Apical" 5	"Subapical" 5	"Pect- oral" 4
V. Boyden and Hart- mann (1946)	(a) According to their Fig. C, Plate 1, #19, upper divi- sion bronchus divides into B ₂ and B ₁₊₃ . The latter divides into B ₁ and B ₃ .	2	"S" (Superior division) 3	"Apical-posterior" (B ₁₊₃) 4	"Apical sub- segmental ramus" B ₁ 5	"Posterior subseg- mental ramus" B ₃ 5	"Ant- erior" B ₂ 4
	(b) According to their Fig. i, Plate 1, #17 (Table 1, Up- per (& modified upper) divi- sion - 1(2)). Upper division bronchus (generation 3) divi- des into bronchus B ₂ (genera- tion 4) and a common stem of bronchi BX _{2b} and apico-post- erior (generation 4). The common stem divides into BX _{2b} (generation 5) and apico- posterior bronchus (genera- tion 5)	2	3	5	6	6	4

Footnote: - The generation of the common stem
of the apico-posterior bronchus
and its lateral branch = 4.

? = doubtful

Table 37

THE GENERATIONS OF THE BRONCHUS OF THE LINGULA (LOWER DIVISION)
OF THE LEFT HUMAN LUNG AND OF ITS SEGMENTAL BRONCHI
(Writer's own findings in 5 bronchial casts and the generations determined
by studying the accounts given by some other authors)

AUTHOR	PATTERN AND/OR SPECIMEN NOS.	GENERATIONS			
		BRONCHUS (International Nomenclature)			
		Upper Lobe Bronchus	Lower Division	Segmental Bronchi	
				Superior	Inferior
I. Writer's own findings	The lingular bronchus divides into two segmental bronchi in all five specimens	2	3	4	4
II. Aeby (1880)	The pattern depicted in his Fig. 7	"V ₁ " 2	Unnamed 3	Unnamed 4	Unnamed 4
III. Ewart (1889)	Only a single pattern described	2	"Cardiac branch of bronchus impar" 3	"Anterior cardiac trunk" 4	"Posterior cardiac trunk" 4
IV. Brock (1946)	When the bronchus to the lingula divides into an upper and a lower branch - the usual arrangement	2	"Lingular bronchus" 3	"Upper branch" - "upper subseg- ment" 4	"Lower branch" - "lower subseg- ment" 4
V. Boyden and Hart- mann (1946)	(a) According to their Table 1, Item, Lower or lingular division 1, Fig. C, Plate 1, Lower division bronchus bi- furcates into bronchi B ₄ and B ₅	2	"Inferior division" "I" 3	"B ₄ " 4	"B ₅ " 4
	(b) According to their Table 1, Item - Lower or lingular division 2 (1) Fig. O, Plate 3, Displaced bronchus B _{4a} arises from the lingular bronchus be- fore it divides into bronchi B _{4b} and B ₅ .	2	3	"B _{4a} " - 4 "B _{4b} " - 5	5
	(c) According to their Table 1, Item, Lower or lingular division 2 (2) Fig. b, Plate 1, Lower division bronchus gives off bronchus BX _{2a} before bifurcating into bronchi B ₄ and B ₅ .	2	3	5	5

Generations of bronchus BX_{2a} = 4.

Table 38

THE GENERATIONS OF THE LOBAR AND SEGMENTAL BRONCHI OF THE LEFT LOWER LOBE OF HUMAN LUNG
(Writer's own findings in 5 bronchial casts and the generations determined
by studying the account given by some other authors)

AUTHOR	PATTERN AND/OR SPECIMEN NOS.	GENERATIONS						
		BRONCHUS (International Nomenclature)						"Subapical Bronchus" (Neil et al., 1938)
		Lower Lobe Bronchus	Segmental Bronchi				Cardiac Bronchus	
			Apical	Anterior Basal	Lateral Basal	Posterior Basal		
I. Writer's own findings	(a) Cardiac bronchus a branch of anterior basal; subapical bronchus, a branch of Common stem of lateral and posterior basal. Specimen 1.	2	3	4	6	6	5	5
	(b) Cardiac bronchus a branch of main stem, subapical bronchus a branch of posterior basal. Specimen 2.	2	3	7	7	6	4	7
	(c) Cardiac bronchus, a branch of anterior basal; subapical bronchus, a branch of posterior basal. Specimen 3.	2	3	5	5	4	6	5
	(d) Cardiac bronchus, a branch of the anterior branch of anterior basal; subapical bronchus a branch of common stem of lateral and posterior basal.	2	3	4	7	7	7	5
	(e) Cardiac bronchus absent; subapical bronchus a branch of posterior basal. Specimen 5.	2	3	4	5	5	absent	6
II. Aeby (1880)	The pattern depicted in his Fig. 7	"Stem Bronchus"	"d ₁ "	"v ₂ "	"v ₃ "	"Stem Bronchus +d ₃ +d ₄ +v ₄ "	absent	"d ₂ "
		2	3	4	6	6		5
III. Ewart (1880)	Retro-cardiac bronchus, a branch of anterior basic; Lesser posterior horizontal bronchus, a branch of posterior basic.	"Bronchus impar"	"Post- erior hori- zontal"	"Anterior basic"	"Axill- ary basic"	"Post- erior basic"	"Retro- cardiac"	"Lesser posterior hori- zontal"
		2	3	4	5	5	5	6
IV. Brock (1946)	(a) Subapical bronchus, a branch of posterior basal - ("typical"); cardiac bronchus, a branch of anterior basal bronchus.	"Upper lobe stem"	"Apical"	"Ant- erior basal"	"Middle basal"	"Post- erior basal"	"Cardiac"	"Sub- apical"
		2	3	4	5	5	5	6
	(b) Subapical bronchus absent; cardiac bronchus a branch of anterior basal	2	3	4	5	5	5	absent
	(c) Cardiac bronchus, a branch of main stem; subapical (?) a branch of posterior basal bronchus	2	3	5	6	6	4	? 7
	(d) Subapical bronchus arises below the apical bronchus from the main stem; cardiac bronchus, a branch of anterior basal.	2	3	5	6	6	6	4
V. Berg, Boyden, and Smith, (1949)	(a) According to their Fig. 5 G & H. # 39; Table IV, Item I, 1. - B ₇ , branch of main stem; B ₈ and B ₉ arise by a common stem.	2	"B ₆ "	"B ₈ "	"B ₉ "	"B ₁₀ "	"B ₇ "	"Sub- superior" "B*" & "BX*" \$
			3	7	7	6	5	B* - 4 BX* - 7
	(b) According to their Fig. 2 B, # 50 - B ₇ , a branch of B ₇₊₈ ; BX* arises from B ₁₀ .	2	3	5	6	6	5	B* - 5 BX* - 7
	(c) According to their Fig. 7 C & D, # 4 - B ₇ , a branch of B ₇₊₈ ; B ₉ , a branch of B ₇ .	2	3	6	7	5	6	B* - 4
	(d) According to their Fig. 6 A, # 8 - B ₇ , a branch of B ₇₊₈ ; BX* a branch of B ₁₀ .	2	3	6	7	7	6	B* (2 bron- chi 4 & 6 BX* - 8

COMPARISON OF THE BRONCHIAL PATTERNS IN MAN AND IN DOG
- WITH SPECIAL REFERENCE TO THE LOBAR BRONCHI

The most characteristic feature of the bronchial tree of the dog is the existence in each lobe of a lobar stem bronchus and the two principal series of rami arising from it.

In the human lung, a structure equivalent to the "lobar stem bronchus" has only been described in the lower lobes as the continuation of Aeby's "stem bronchus". Again it is only in these lobes that anything like a serial arrangement, though not very obvious, may be said to exist—the dorsal "series" being represented by the apical segmental bronchus and the "subapical" bronchus or bronchi of Neil and Gilmour (or "sub-superior" B* or BX* of Boyden), and the ventral "series" by the anterior and the lateral basal bronchi. In no other lobe of the human lung has the existence of an axial stem with a serial arrangement of its branches been described.

Before going any further it is necessary to review the current conceptions with regard to the lobar bronchi of the human lungs. These may first be considered lobe by lobe.

Right Upper Lobe

According to the generally accepted view, the bronchus to the right upper lobe terminates after a short course (Ewart, 1.2 cms; Brock, 1.25 cm; Nelson, 1.0 cm; Foster-Carter, 1.0 cm).

Three modes of its termination have been described:-

(1) Bifurcation has been described by Ewart (1889).

Dwight Davis (1929) has described it as a normal finding. Behr and Huizinga (1938) found it in 45 out of 108 lobes, D'Hour (1946) in 17.5 per cent of 40 lobes, Boyden and Scannell (1948) in 54 per cent of 50 specimens, and Smyth (1949) in 2 out of 8 lungs.

According to Huizinga and Smelt (1949) it is a rare anatomical variation.

(2) Trifurcation has been represented by Aeby (1880) in his Fig. 7 (see Fig. 63). It has been described by Hasse (1892) quoted by Huizinga and Smelt (1949), Ewart (1889), Nelson (1932), and Huizinga and Smelt (1949)—as a pattern in majority of specimens, Behr and Huizinga (1938) in 63 out of 108 lobes, Pierret and co-workers (1938), Foster-Carter (1942), Brock (1946), D'Hour (1946)—in 72.5 per cent of 40 lobes, Boyden and Scannell (1948)—in 46 per cent of 50 lungs, and Smyth (1949) in 6 out of 8 lungs.

Ewart viewed trifurcation as consisting of "two bifurcations following each other very rapidly". Later, Brock, and Smyth have expressed the same view.

(3) A division into four bronchi, a "quadripartite division" (Huizinga and Smelt, 1949) or "quadruvial pattern" (Boyden and Scannell, 1948), has been described by many, but the simultaneousness of division has not been clearly emphasised by most of the authors. However, Foster-Carter (1942), Appleton (1945) and D'Hour (1946) have mentioned instances of strictly quadripartite division.

As a normal finding the existence of a "separate fourth branch of the right upper lobe bronchus" ("axillary" bronchus) has been denied by Foster-Carter (1943 and 1952).

Brock found a "true primary axillary bronchus" in only one out of 180 bronchograms and none in a series of 40 injected specimens. He explains how Churchill and Belsey (1939) mistook the oval shadow cast by right upper lobe bronchus end on, in a skiagram, as the shadow of the axillary bronchus. He too,

therefore, denies the existence of a "true primary axillary broncho-pulmonary segment" and, thus, that of the fourth branch.

Boyden and Scannell (1948) do not describe a single instance in which four bronchi shared a single orifice. Thus a quadrupartite division, if it exists at all, is a rare occurrence.

Right Middle Lobe

The bronchus of the right middle lobe has a length of 0.8 to 2.6 cms. (Ewart 2 cms; Nelson 2 cms; Brock 1 to 1.5 cms; Boyden and Hamre 1.2 to 2.6 cms - mean length 1.8 cms; Liard 1.2 - 2.2 cms; Overholt and Langer 0.8 - 1.2 cms).

Two modes of its termination have been described:-

(1) Bifurcation has been described by Ewart (1889), Neil et al (1938), Peirce and Stocking (1939), Adams and Davenport (1942), Foster-Carter (1942), Huizinga and Pothoven (1943), Miscall and Cornell (1943), Foster-Carter (1944), Brock (1946), Boyden and Hamre (1949), Huizinga and Smelt (1949), Overholt and Langer (1949) and Smyth (1949) in 8 out of 10 specimens.

(2) Trifurcation has been described by Pierce and Stocking (1939), Boyden and Hamre (1951) in 2 per cent of 50 lobes, and Smyth (1949) in 2 out of 10 specimens. Ewart explains trifurcation as apparent only as he does for the right upper lobe.

Left Upper Lobe

The length of the left upper lobe bronchus (Bronchus Impar of Ewart) is 1 - 1.5 cms (Ewart 1.3 cm; Nelson 1 cm. and Brock 1 - 1.5 cm).

It is usually described to bifurcate into its upper and lower divisions, but a termination by a trifurcation has been described by Huizinga and Behr (1940) in 21 out of 125 specimens.

Boyden and Hartmann (1946) - in 26 per cent of 50 specimens, Foster-Carter (1952) - as being occasionally apparent, and Smyth (1949) in 1 out of 10 casts.

The upper division bronchus has a length of 1 cm. according to Brock, and 0.5 cm according to Nelson. This, too, is usually described to terminate by a bifurcation into the apico-posterior and the anterior segmental bronchi. But a trifurcation has been described by Brock (1946) as occurring occasionally, by Smyth (1949) - in 2 out of 10 specimens, and Boyden and Hartmann (1946) - in 18 per cent of 50 specimens.

The lingular bronchus, after a short course of 1 - 2 cms, (Ewart 1.2 cm; Brock 1 - 2 cms, and Nelson 2 cms), terminates constantly by a bifurcation into the two segmental bronchi. But a trifurcation has been described in 1 out of 10 casts by Smyth (1949).

Boyden and Hartmann found a bifurcation in 78 per cent; in the other 22 per cent, bifurcation was preceded by the origin of a "posterior" branch. Thus in their 100 per cent specimens the mode of termination was bifurcation.

Right and Left Lower Lobes

According to Ewart, on both sides "any distinct trace of the 'bronchial stem' of Aeby is lost below the level of the upper third of the lower lobe".

On the right side, according to Ewart, it "bifurcates into the terminal trunks, the axillary-basic and the posterior-basic". The findings of Neil and others (1939), Huizinga and Smelt (1949) and Foster-Carter (1942) are in agreement with this.

Trifurcation of the right lobar bronchus into the anterior,

lateral and posterior basal bronchi, has been described by Brock (1946) - in 5 out of 30 lobes, by Smyth (1949) - in 1 out of 10 specimens, and has been mentioned by Huizinga and Smelt (1949). According to Brock, this is an "apparent trifurcation".

Others have stated that the lobar bronchus is continued into the posterior basal bronchus - Foster-Carter (1944 and 1952), Brock (1946), Temple and Evans (1950), and Smith and Boyden (1949).

On the left side a trifurcation of the basal trunk of the lobar bronchus, i.e., below the origin of the apical bronchus, has been described to be more common than on the left side. Ewart interprets it, as he does all other trifurcations, as "spurious". Brock (1946) found it in 28 out of 30 cases, Smyth (1949) in 6 out of 10, and both maintain that it is only apparent. Berg, Boyden and Smith (1949), however, found it only in 13 per cent of 50 specimens, but they described a trifurcation when the keels of the bronchi were not more than 4 mm. apart. It is thus clear that a true trifurcation has not been described by any.

Bifurcation into various combinations of basal bronchi was found in 87 per cent of 50 specimens by Berg, Boyden and Smith (1949).

Others have, as on the right side, described the stem to be continued into the posterior basal bronchus, such as Nelson (1934) and Foster-Carter (1944 and 1952).

Writer's own findings of the mode of termination of lobar bronchi, studied in 5 human bronchial casts, are summarised below:-

	<u>No. of Specimens</u>
<u>Right Upper Lobe Bronchus</u>	
Bifurcation into anterior bronchus, and a common stem of apical and posterior bronchi.	1
Trifurcation into apical, posterior and anterior bronchi	4
<u>Right Middle Lobe Bronchus</u>	
Bifurcation into lateral and medial bronchi	5
Trifurcation	0
<u>Left Upper Lobe Bronchus</u>	
Bifurcation into upper and lingular (lower) division bronchi	5
Trifurcation	0
<u>Upper Division Bronchus</u>	
Bifurcation into apico-posterior and anterior bronchi	5
Trifurcation	0
<u>Lingular (lower) Division Bronchus</u>	
Bifurcation into superior and inferior bronchi	5
Trifurcation	0
<u>Right Lower Lobe Bronchus</u>	
Bifurcation of basal trunk (i.e., below the origin of medial basal bronchus) into a common trunk of anterior and lateral basal bronchi, and posterior basal bronchus.	2
Stem bronchus continued into posterior basal bronchus	3
Trifurcation	0
<u>Left Lower Lobe Bronchus</u>	

contd.

<u>Left Lower Lobe Bronchus</u>	<u>No. of Specimens</u>
Bifurcation of basal bronchus into a common trunk for anterior and lateral basal bronchi, and posterior basal bronchus.	2
Bifurcation into lateral basal and posterior basal bronchus.	2
Stem bronchus continued into posterior basal bronchus.	1
Trifurcation	0

From the foregoing it is clear, that the presence of the homologue, of what has been described by the present writer in the dog as a "lobar stem bronchus", is only recognised in the lower lobes of the human lung, as the continuation of Aebys "stem bronchus", which terminates at different levels, either by a bifurcation or a trifurcation, in the upper part of the lobe, or is continued into the posterior basal bronchus.

No mention has been made in literature of the existence of a "stem bronchus" in other lobes. Huizinga and Behr (1938), however, seem to have attempted to find out in the right upper lobe as to which of the segmental bronchi is the continuation of the lobar bronchus by comparing the calibre of the bronchi, and concluded that this approach is not helpful.

The five human bronchial casts were, therefore, further examined for the existence of any axial stems with a serial arrangement of their branches resembling those in dog.

Obviously the presence of such an arrangement should be looked for in those segments of the human lungs which have been shown to correspond to those areas of the dog's lungs which are traversed by the lobar stem bronchi. Such segments

of the human lungs are enumerated below. (The corresponding areas of the dog's lungs may be referred to in Table 32.)

1. Anterior segment of the right upper lobe.
2. Medial segment of the right middle lobe.
3. Posterior basal segment of the right lower lobe.
4. Medial basal segment of the right lower lobe.
5. Anterior segment of the left upper lobe, or, according to the alternative interpretation given in Table , the apical segment of the left upper lobe.
6. Inferior segment of the lingular division of left upper lobe.
7. Posterior basal segment of the left lower lobe.

It was found that among these areas in none, except the anterior segment of the right upper lobe, was a bronchus, resembling a lobar stem bronchus with its two series of branches, recognisable. The evidence of the existence of such an arrangement in the right upper lobe and the arguments in favour of the anterior segmental bronchus being considered as the continuation of the lobar bronchus, are discussed in the succeeding pages.

The foregoing at once suggests that the anterior segmental bronchus should be morphologically considered as the continuation of the lobar bronchus. This view is further supported by the following additional observations:-

This method of denoting bronchus in the lung was used to make it conform to the method used for the dog and to indicate corresponding series of bronchi. The bronchi of the dog are denoted in Fig. 44, corresponding to the human bronchi in Fig. 45, and the human bronchi in Fig. 46, corresponding to the dog's bronchi in Fig. 47. The letters A and B indicate the anterior and posterior segments of the right upper lobe respectively.

THE EVIDENCE OF THE EXISTENCE OF A "LOBAR STEM BRONCHUS"
IN THE UPPER LOBE OF RIGHT HUMAN LUNG

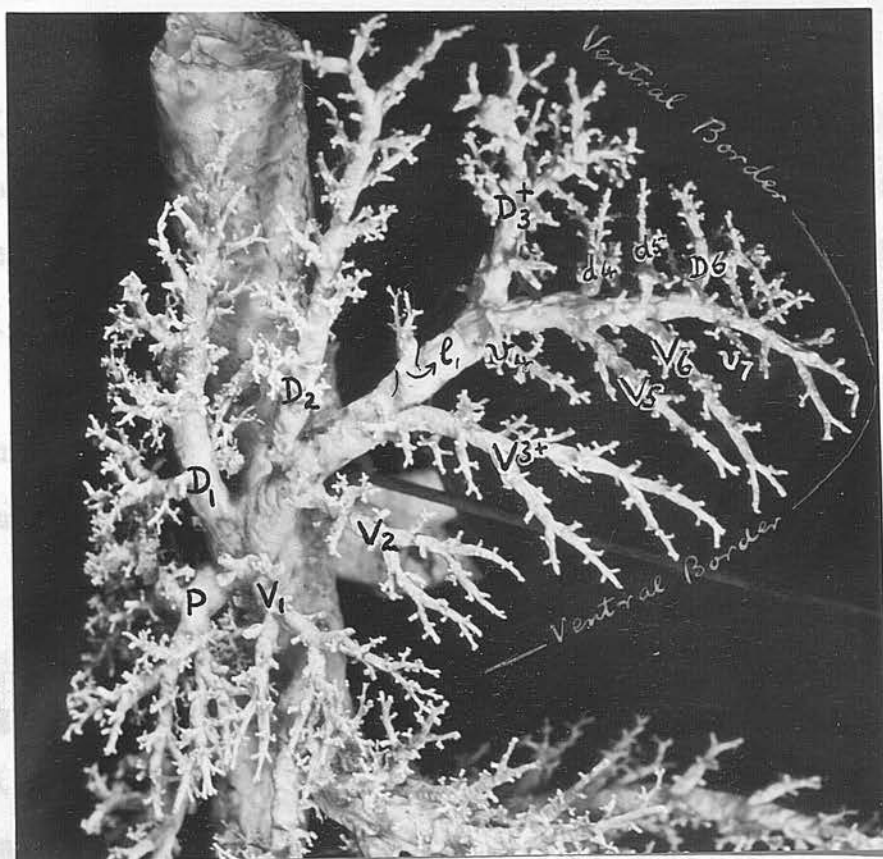
Fig. 64B is a supero-antero-lateral view of a bronchial cast of the right upper lobe. In it the three segmental bronchi originate according to the usually described trifurcate pattern.

In this Figure, the anterior segmental bronchus can clearly be seen to run through the lobe from its origin, at the site of "trifurcation", to the ventral end of the lobe. From it can be seen to arise two large rami which are directed almost ventrally with a superior inclination, and three large rami which run towards the margin of the lobe, which forms the border of the horizontal fissure. The former two branches fall in series with the apical bronchus, which corresponds to bronchus D₁ of dog, and together the three bronchi have been labelled as D₁, D₂ and D₃ in Fig. 64B. The other three branches of the anterior segmental bronchus fall in series with the posterior segmental bronchus, which corresponds to bronchus P of dog. Together these four bronchi have been denoted P, V₁, V₂ and V₃ in the same Figure.* In each of the remaining four specimens of human bronchial casts a similar arrangement was recognisable in the upper lobes.

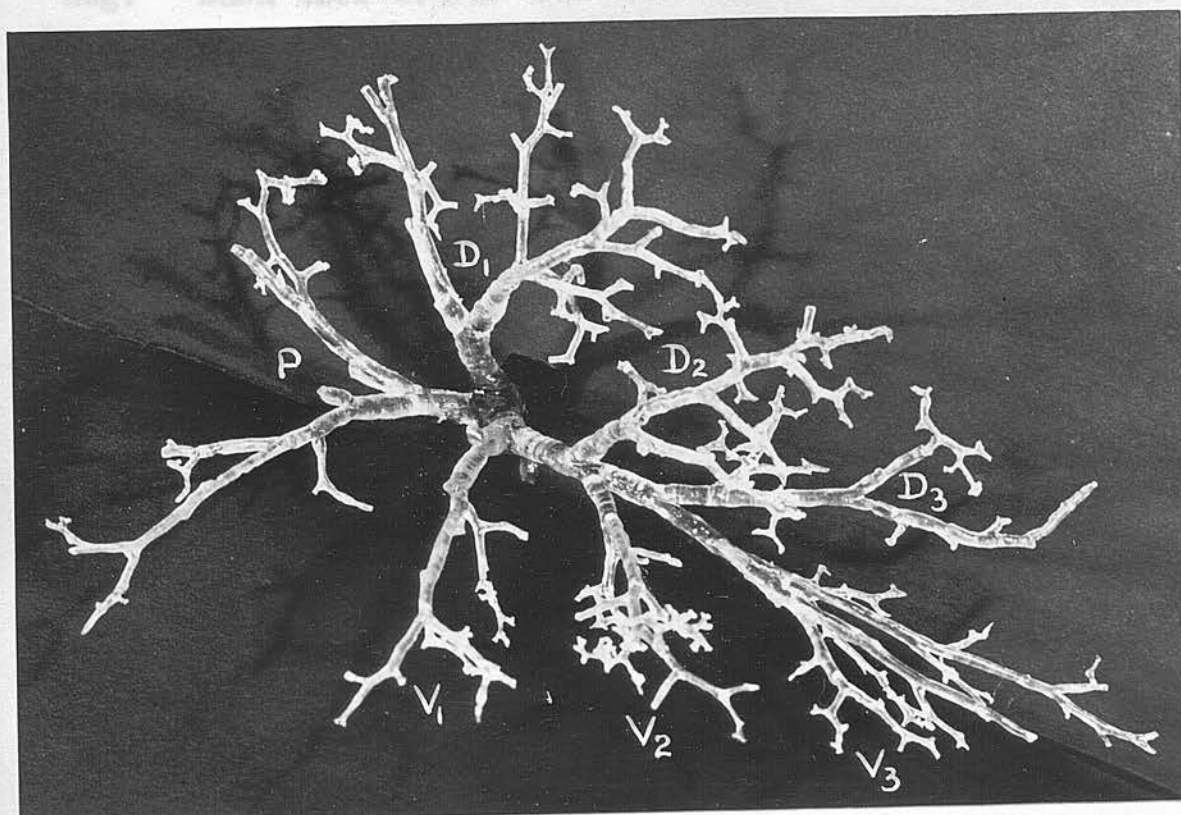
A comparison of the arrangement of bronchi in the right apical lobe of dog and the right upper lobe of man, may be made by comparing Figs. 64A and 64B.

The foregoing at once suggests that the anterior segmental bronchus should be morphologically considered as the continuation of the lobar bronchus. This view is further supported by the following additional observations:-

* This method of denoting branches in the human lobe has been adopted to make it conform to the method used for the dog and to indicate corresponding series of bronchi. Thus bronchi D₁, D₂ and D₃ in Fig. 64B, correspond to the dorsal series and bronchi P, V₁, V₂ and V₃ correspond to the ventral series in the dog's lobe, although these letters do not indicate their direction as they do in dog.



A. DOG.



B.
MAN.

Fig. 64 A & B. Comparison of the Bronchi of Right Apical Lobe of Dog's and Right Upper Lobe of Human Lung.

(1) The area supplied by the anterior segmental bronchus is morphologically identical to the area $D_2+V_1+V_2+T$ of dog's apical lobe, (Table 32) which contains the lobar stem bronchus.

(2) The anterior segmental bronchus in man is directed to the ventral end of the lobe. The lobar stem bronchus in dog terminates, in the majority of lobes, at the corresponding Terminal end of the lobe. The difference in their directions and in the directions of their branches can be explained to be due to the "rotation" of the right upper lobe of the human lung discussed before (page 237).

(3) The anterior segmental bronchus, curving round the heart in man, resembles in this respect the lobar stem bronchus of dog. Each lies nearer the mediastinal than the costal surface.

(4) The anterior segment is the largest of the three segments of the right upper lobe, and so is the corresponding area in dog.

The position of the lobar stem bronchus in the human and in the dog's lobe, and the planes in which the corresponding series of these branches lie, are diagrammatically represented in Fig. 65 . It will be noticed that the angle between the planes of the dorsal and the ventral series of bronchi in dog approaches 180 degrees. In man this angle is reduced to a little over 90 degrees. The two series are otherwise related to corresponding mediastinal and fissural surfaces. This difference in the angles can be explained to be associated with the lateral expansion of the human lung.

Considering the bronchus of the human upper lobe to be continued into the anterior segmental bronchus as a "lobar stem bronchus", the order of branches arising from it, designated

as explained above, is recorded in Chart VIII.

It MAN be noticed that in Specimens I to IV DOG and the apical segmental bronchi (P and B_1 respectively) originate at the same level. In Specimen V, these two bronchi originate by a common stem. The arrangement of the former four segments conforms to the trifurcate pattern, and the in the latter specimen to one of the bifurcate patterns described in literature.

It will also be noticed from the Chart that the first number of bronchi originate from the lobar stem branches and the order of appearance of branches on the stem is not uniform. These facts agree with those in literature.

To summarize the findings of the present study, the right upper lobe of human lung is characterized by two main apical bronchi, identical with that of the right apical lobe of dog's lung.

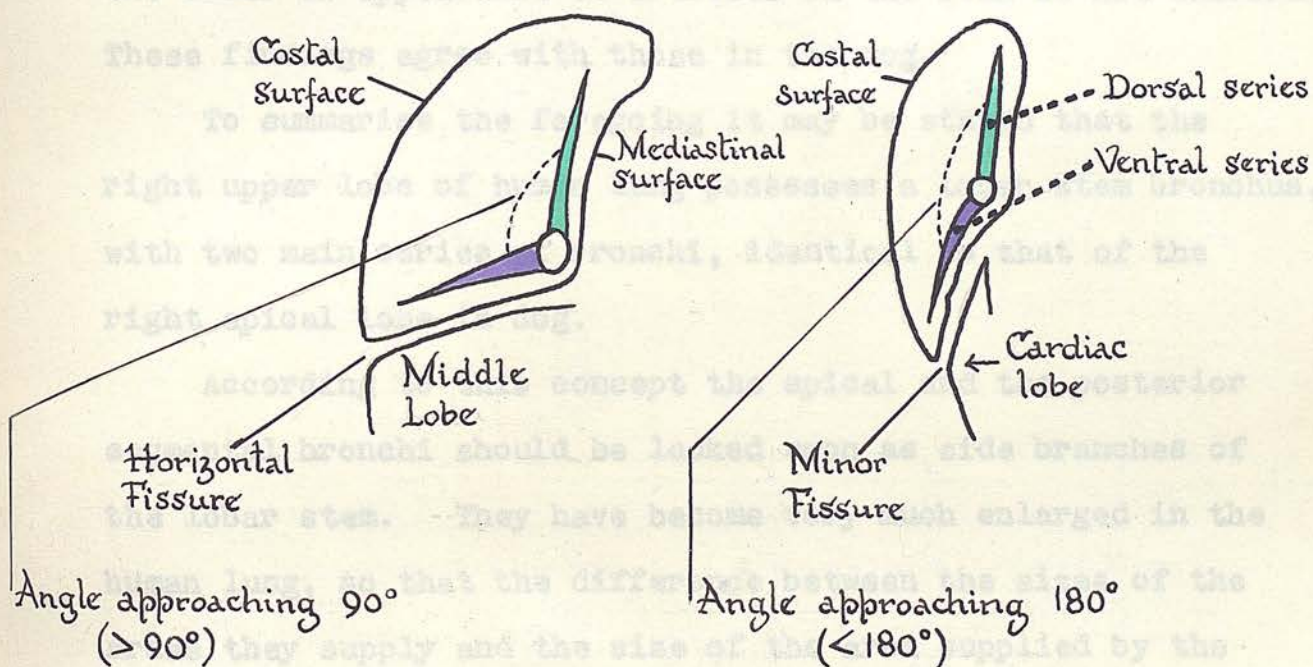


Fig. 65

Schematic drawings of cross-sections of the right upper lobe of human and right apical lobe of dog's lung, to indicate the planes of the two main corresponding series of bronchi.

A - Plane of Section.

as explained above, is recorded in Chart VIII.

It will be noticed that in Specimens I to IV the posterior and the apical segmental bronchi (P and D₁ respectively) originate at the same level. In Specimen V, these two bronchi originate by a common stem. The arrangement in the former four specimens conforms to the trifurcate, and that in the latter Specimen to one of the bifurcate patterns described in literature.

It will also be noticed from the Chart that no fixed number of bronchi originate from the lobar stem bronchus and the order of appearance of branches on the stem is not uniform. These findings agree with those in the dog.

To summarise the foregoing it may be stated that the right upper lobe of human lung possesses a lobar stem bronchus, with two main series of bronchi, identical to that of the right apical lobe in dog.

According to this concept the apical and the posterior segmental bronchi should be looked upon as side branches of the lobar stem. They have become very much enlarged in the human lung, so that the difference between the sizes of the areas they supply and the size of the area supplied by the continuation of the lobar stem bronchus (i.e., the anterior segment) becomes less marked. When they originate at the same level from the lobar bronchus, the appearance of trifurcation is produced.

CHART. VIII

Branches of the Lobar Stem Bronchus
of Right Upper Lobe of Human Lung.
(5 specimens)

Specimen
Numbers.

Numerical Order of Branches.-

1 2 3 4 5 6 7 8 9 10 11

1 P/D₁ V₁ D₂ V₂ D₃ V₃ m₁

2 P/D₁ V₁ V₂ D₂ m₁ V₃ D₃ m₂ V₄

3 P/D₁ V₁ D₂ V₂ D₃ m₁ V₃ m₂ V₄[?] D₄[?]

4 P/D₁ V₁ D₂ V₂ m₁

5 P^{*}/_{D₁} V₁ D₂ V₂

∴ The posterior segmental bronchus (P) and the apical segmental bronchus (D₁) originate by a common stem. That is why they have been placed in the same square.

THE PRESENCE OF THE LOBAR STEM BRONCHUS IN
HUMAN RIGHT UPPER LOBE - Reconciliation of
this View with Views existing in Literature

Different authors have described the bronchi of right upper lobe of the human lung in varying degrees of detail. They vary from a simple description of a division into three bronchi to a most detailed and minute account of the ramification of each one of these three bronchi, such as the one given by Ewart and later by Appleton (1945), and Boyden and Scannell (1948).

The recognition of a lobar stem bronchus and a serial arrangement of its branches in the right upper lobe necessitates a correlation of the writer's own account of the anterior segmental bronchus, into which the lobar bronchus is continued, with the accounts given by others. Those of Ewart, Appleton, and Boyden and Scannell are considered below in chronological order.

Ewart's Account

Ewart's views on the lobar bronchus have already been given. In his monograph he makes no mention of the number of specimens on which he based his account. He describes the "pectoral stem" as arising first, and he calls the "remainder" as the "axillary apical" bronchus, which is the common stem of the "axillary" and "ascending apical" bronchi (corresponding to the "posterior" and the "apical" segmental bronchi). He was obviously dealing with one or more of those relatively less common specimens in which the posterior and the apical bronchi are known to arise by a common stem. (Compare with Specimen M5 of the present writer, Chart VIII).

Lack of recognition of the lobar stem bronchus led Ewart to give an account which is most complicated. Yet a perusal

of his account shows that a complete description of this stem is contained within his account, not described as a single whole, but split up into successive fragments, each given a different name. This can only be shown by quoting Ewart.

Fig. 66 is a photograph of the bronchial cast of the right upper lobe (same as in Fig. 64B). It has been specially selected as it conforms to Ewart's account very closely. It has been labelled according to his terminology. It should be constantly referred to while reading his description reproduced below. (His own illustrations are inadequate for this purpose.)

"The pectoral stem barely exceeds 1 - 3 cm. in length, but is of substantial thickness. Arising from the anterior extremity of the upper lobe bronchus, at the seat of spurious trifurcation, it contributes the first part of the semi-circular curve forwards and inwards which carries the termination of the horizontal sternal bronchus* to a point in the anterior pulmonary fringe nearly opposite to the bifurcation of the trachea.

"The two divisions from this stem lie side by side at their origin, not, however, in a strictly horizontal plane. The outer branch or mid-pectoral is slightly superior to the internal or sterno-pectoral bronchus. The Sterno-pectoral Bronchus, of same length as its parent, continues the semi-circular curve, and divides into the ascending sterno-pectoral and the horizontal pectoral bronchi.

"..... the Ascending Sterno-pectoral rises forwards

* Horizontal sternal bronchus not described by Ewart.

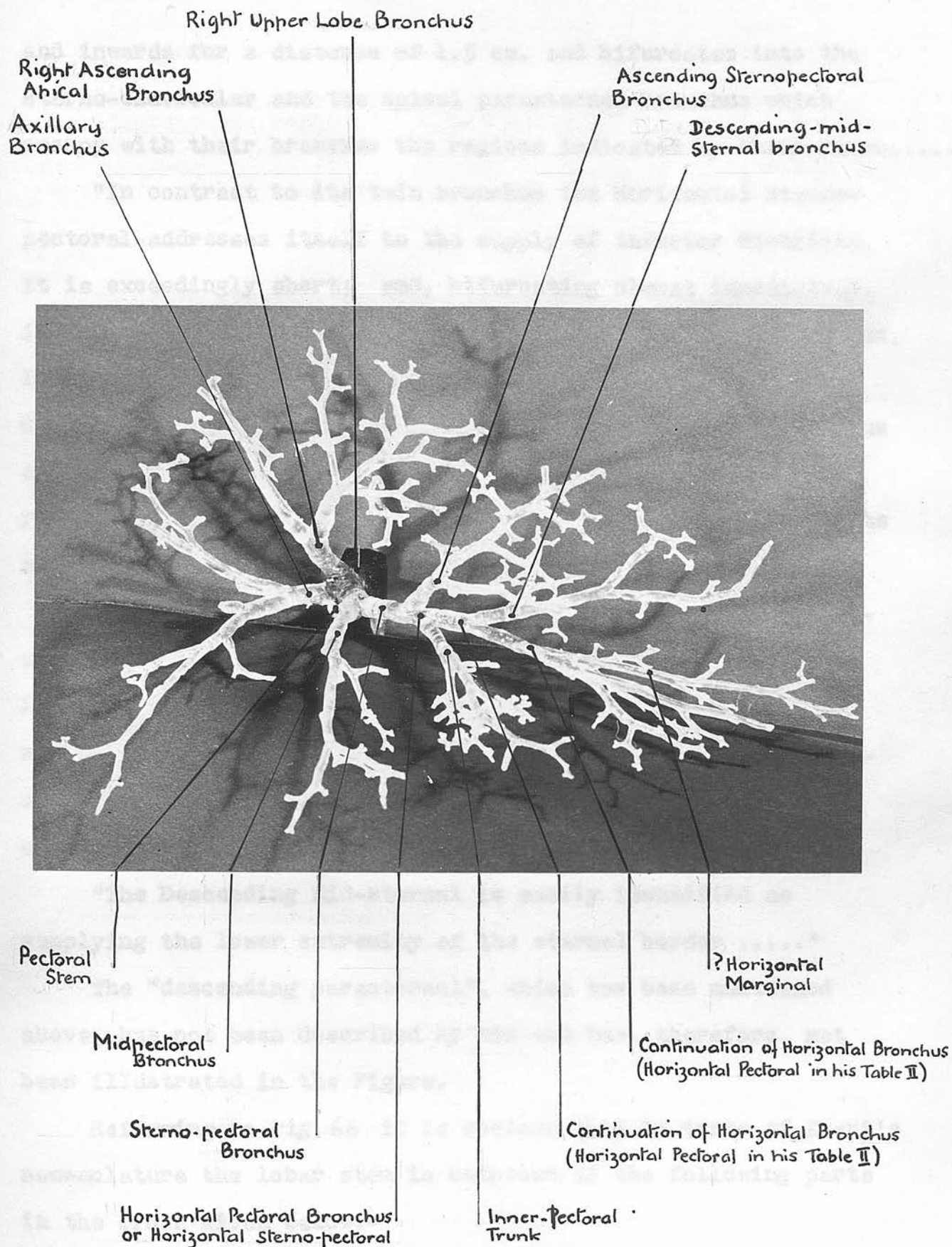


FIG. 66 Cast of the Bronchi of Upper Lobe of Right Human Lung labelled to illustrate Ewart's account.

and inwards for a distance of 1.5 cm. and bifurcates into the sterno-clavicular and the apical parasternal bronchus which occupy with their branches the regions indicated by their names.....

"In contrast to its twin bronchus the Horizontal Sterno-pectoral addresses itself to the supply of inferior districts. It is exceedingly short; and, bifurcating almost immediately, it yields the inner-pectoral trunk, and by a second bifurcation, 1 cm. distant from the first, the descending mid-sternal. Continuing its forward and inward curve the horizontal bronchus distributes a descending parasternal to the corresponding region of the anterior surface, and several marginal branchlets to the pulmonary fringe.

"The Inner-pectoral Trunk, of smaller size than the horizontal pectoral, and not exceeding, in the cast, 1 cm. in length, proceeds forwards and a little downwards. After a bifurcation which gives rise to the deep inner-pectoral inter-lobar, it supplies branchlets to the inner portion of the upper lobe.

"The Descending Mid-sternal is easily identified as supplying the lower extremity of the sternal border"

The "descending parasternal", which has been mentioned above, has not been described by him and has, therefore, not been illustrated in the Figure.

Referring to Fig. 66 it is obvious that in terms of Ewart's nomenclature the lobar stem is composed of the following parts in the order given below:-

- (1) "Right upper lobe bronchus" - proximal to its "spurious trifurcation"
- (2) "Pectoral stem"
- (3) "Sterno-pectoral bronchus"

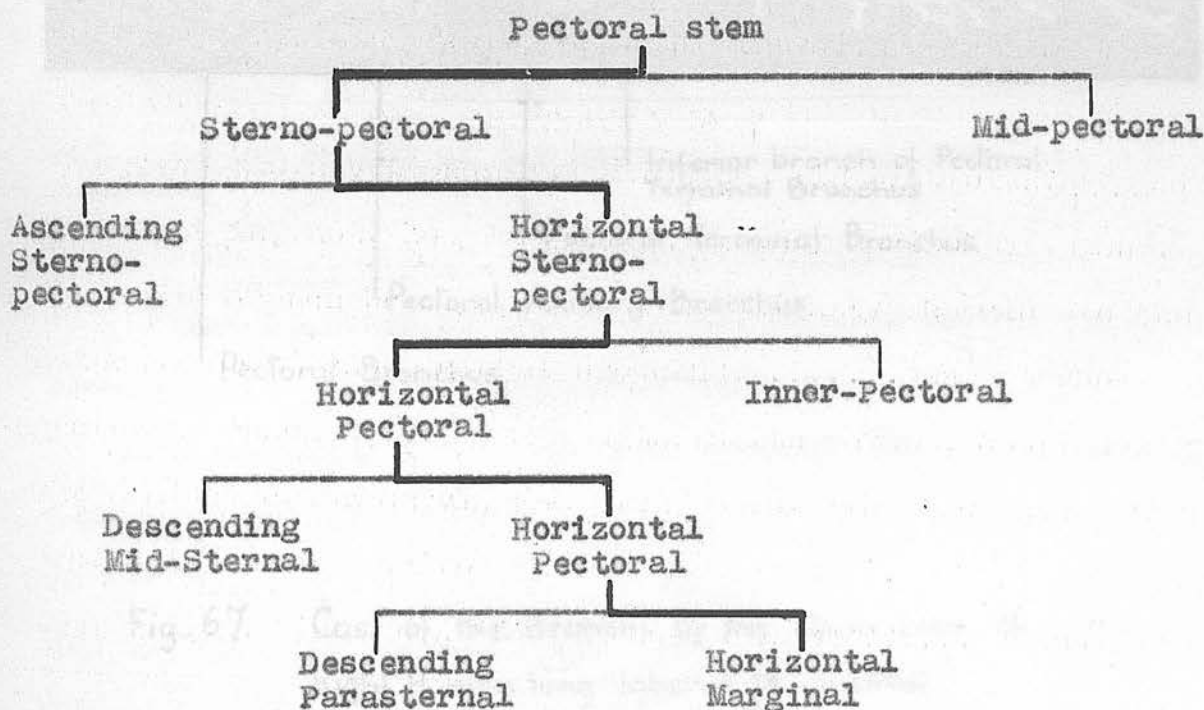
- (4) "Horizontal pectoral bronchus" or "Horizontal sterno-pectoral"
- (5) Continuation of "Horizontal bronchus" - unnamed in text ("Horizontal Pectoral" in his Table II)
- (6) Continuation of (5) - referred to again as "Horizontal Pectoral" in Table II.
- (7) ? "Horizontal marginal".

It is interesting to note, if reference is made to Table 4/ derived from his Table II, of "Right Pectoral Distribution", that from sterno-pectoral bronchus onwards the adjective, "horizontal", defines all those branches which make up the lobar stem bronchus, described by the present writer.

It may also be noted that the terminology used by Ewart is confusing and it is made more confusing by lack of harmony between names used in text and the names given in his Table II.

Table 4/.

EWART'S PECTORAL DISTRIBUTION
(His Table II)



The thick line connects parts forming the lobar stem bronchus.

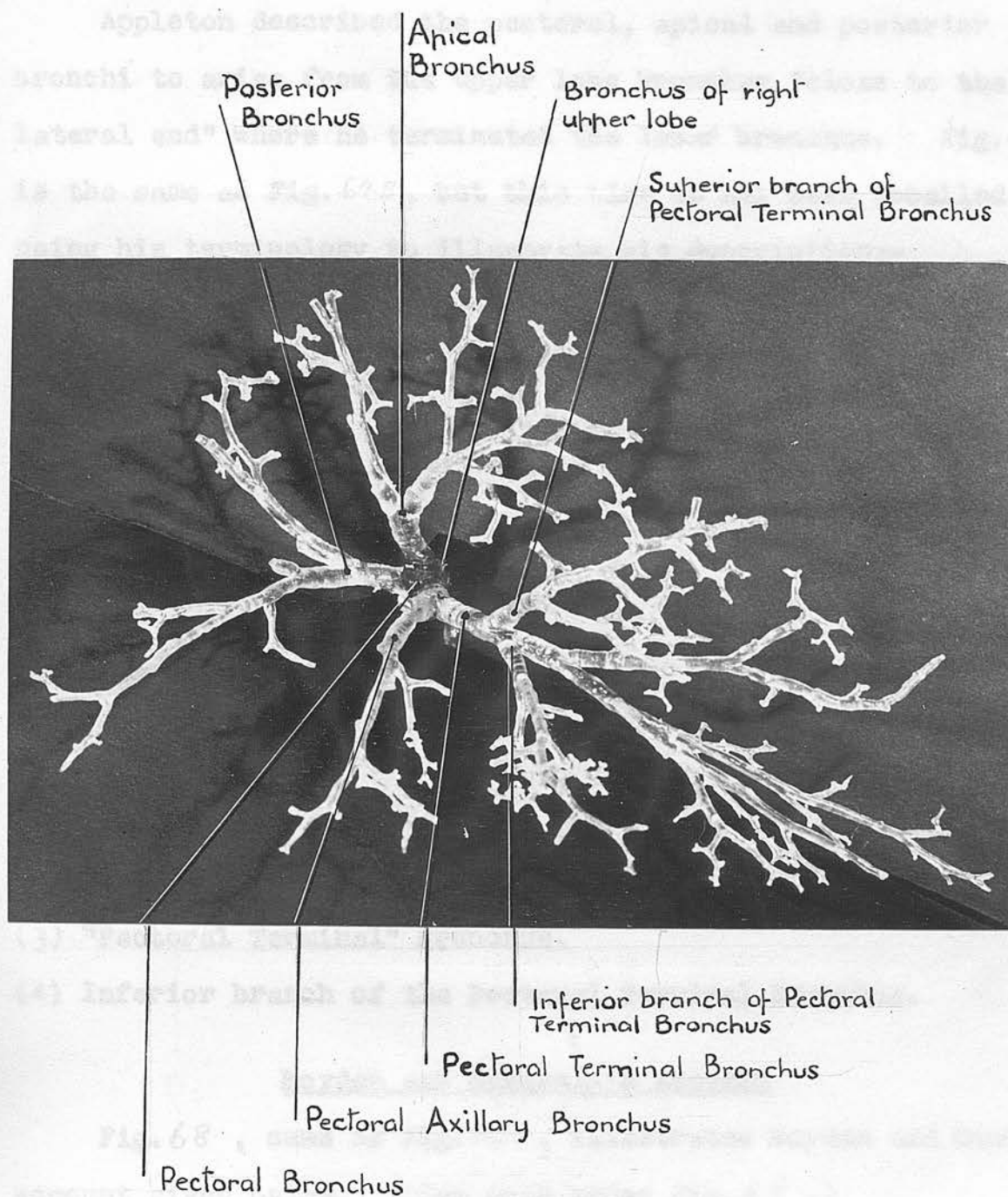


Fig. 67 Cast of the Bronchi of the Upper Lobe of Right Human lung labelled to illustrate Appleton's account.

Appleton's Account

Appleton described the pectoral, apical and posterior bronchi to arise from the upper lobe bronchus "close to the lateral end" where he terminated the lobar bronchus. Fig. 67 is the same as Fig. 64B, but this time it has been labelled using his terminology to illustrate his description:-

"The pectoral bronchus generally divides into 'pectoral axillary' and 'pectoral terminal' bronchi (the 'anterolateral anterior' and 'anterolateral external' of Foster-Carter), which respectively ventilate 'axillary' and 'terminal' sub-segments. The pectoral terminal bronchus runs forwards close to the mediastinal surface towards the anterior margin of the lung and divides into superior and inferior branches."

Thus, using Appleton's terminology, the lobar stem bronchus is composed of:-

- (1) Bronchus of the right upper lobe.
- (2) "Pectoral Bronchus".
- (3) "Pectoral Terminal" Bronchus.
- (4) Inferior branch of the Pectoral Terminal Bronchus.

Boyden and Scannell's Account

Fig. 68, same as Fig. 64B, illustrates Boyden and Scannell's account given below. (See note under Fig. 68.)

"..... the right upper lobe bronchus subdivides into 3 segmental bronchi, apical (B_1) anterior (B_2) and posterior (B_3).....

"The second or anterior trunk (B_2) divides into a lateral (a) and an anterior ramus (b) (the pectoral axillary and pectoral terminal bronchi of Appleton). The former distributes laterally its superior branch (B_{2a1}) supplying the costal surface,

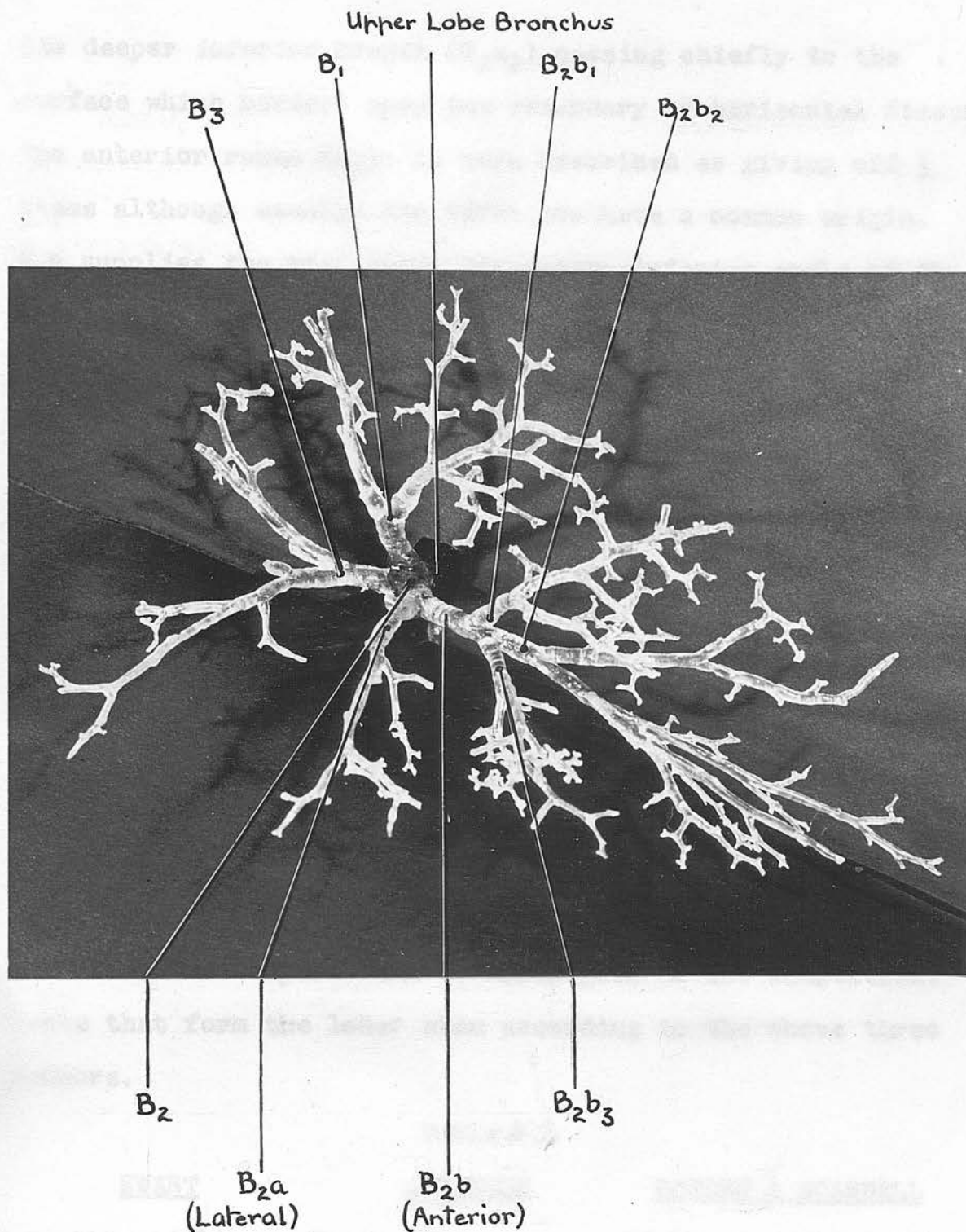


FIG. 68. Cast of the Bronchi of the Upper Lobe of Right Human Lung labelled to illustrate Boyden and Scannell's account.

Note — According to Boyden & Scannell B_{2b_1} & B_{2b_2} usually have a common origin. In this specimen B_{2b_2} and B_{2b_3} possess a common stem. Only if B_{2b_1} had "shifted" distally beyond B_{2b_3} , or B_{2b_3} had "shifted" proximal to B_{2b_1} , this specimen would have served Boyden & Scannell's account exactly.

its deeper inferior branch (B_2a_2) passing chiefly to the surface which borders upon the secondary or horizontal fissure. The anterior ramus (B_2b) is here described as giving off 3 stems although usually the first two have a common origin. B_2b_1 supplies the area above the antero-inferior angle of the right upper lobe. B_2b_2 supplies the region of the angle, B_2b_3 distributes to the adjacent portion of the horizontal fissure."

Referring to Fig. 68, it will be noticed that the following bronchi, in Boyden and Scannell's terminology, constitute the lobar stem bronchus:-

- (1) "Right upper lobe bronchus"
- (2) " B_2 "
- (3) " B_2b ", common stem of B_2b_2 and B_2b_3 (but, according to their description, it is usually B_2b_1 and B_2b_2 which possess a common stem).
- (4) B_2b_2 .

Table 4-2 compares the terminologies of the constituent parts that form the lobar stem according to the above three authors.

Table 4-2

<u>EWART</u>	<u>APPLETON</u>	<u>BOYDEN & SCANNELL</u>
1. Bronchus right upper lobe	Upper lobe bronchus	Right upper lobe bronchus
2. Pectoral stem	Pectoral bronchus	B_2
3. Sternopectoral	Pectoral Terminal	B_2b
4. Horizontal pectoral (or Sternopectoral bronchus	Inferior branch of pectoral terminal	Common stem of B_2b_1 and B_2b_2 .
5. Horizontal pectoral	-	Continuation into B_2b_2

contd.

Table 42 contd.

	<u>EWART</u>	<u>APPLETON</u>	<u>BOYDEN AND SCANNELL</u>
6. Horizontal pectoral	-	-	-
7. ? Horizontal marginal	-	-	-

From this Table it will be seen that according to Ewart the main stem has been described in 7 parts. The first 4 are contained in Appleton's and the first 5 in Boyden and Scannell's description. Others have paid attention to the first one or two components or what may be called the "inter-nodes" of the lobar stem bronchus.

From the foregoing it is clear that the detailed accounts of Ewart, Appleton, and Boyden and Scannell are not inconsistent with the conception of the lobar stem bronchus with its serial branches, introduced by the present writer.

MORPHOLOGICAL RESEMBLANCE BETWEEN RIGHT PECTORAL
AXILLARY BRONCHUS OF HUMAN LUNG, AND BRONCHUS V₁
OF THE RIGHT APICAL LOBE OF DOG

It is considered appropriate, at this stage, to point out the morphological similarity between these two bronchi.

The correspondence between the right anterior (or pectoral) segmental bronchus and the lobar stem bronchus of the right apical lobe of dog, after it has given off bronchi P and D₁, has already been pointed out.

The first branch given off by the anterior segmental bronchus is the pectoral axillary bronchus. This branch supplies an area which is situated between the posterior segment and the remaining anterior segment, and is projected on the costal and the interlobar surface for the horizontal fissure. It has been labelled V₁ in Fig. 64B.

The corresponding branch in dog is bronchus V₁ of the right apical lobe (compare Figs. 64A and 64B). It supplies segment V₁ (Fig. 32A+B), an area identical to the area supplied by the pectoral axillary bronchus, in its position and in being projected on corresponding surfaces.

do not take into consideration the relationship of vessels to bronchi, which form the only landmarks as definite clues to their identity. The only authors who have given the relationship of blood vessels to bronchi are Appleton (1945), and Heyden and co-workers. Their accounts will be made the basis for comparison, and their terminology will be used.

The veins are situated intersegmentally, i.e., along planes which separate the segments. The corresponding intersegmental planes in the lungs of dog are

COMPARISON OF PULMONARY BLOOD VESSELS

Introductory Remarks

In view of a different mode of development of the pulmonary blood vessels, the same strict principles of homology, as applied to bronchi, are not applicable to them. Strictly speaking, their comparison should be restricted to those vessels which supply the absolutely homologous areas listed on page 260 under items V and VI. Thereby, at segmental level, the comparison would be limited only to the vessels of the apical segment of the left lower lobe of human, and segment D₁ of the left diaphragmatic lobe of dog's lung. The comparison of the vessels, therefore, will be made ^{the blood vessels of} between those morphologically corresponding areas which are shown in Table 32. And, therefore, it may be kept in mind that in the succeeding comparative account, not all the corresponding vessels pointed out supply absolutely homologous bronchial territories.

Different authors have introduced different terminologies for the pulmonary blood vessels of the human lung. A correlation of their accounts is difficult because most of the authors do not take into consideration the relationship of vessels to bronchi, which form the only landmarks as definite clues to their identity. The only authors who have given the relationship of blood vessels to bronchi are Appleton (1945), and Boyden and co-workers. Their accounts will be made the basis for comparison, and their terminology will be used.

The veins are situated intersegmentally, i.e., along planes which separate the segments. The corresponding intersegmental planes in the lungs of dog and of man will be made the basis

for their morphological identity.

It may be added that, in comparing vessels, minute arteries and veins will be omitted.

COMPARISON BETWEEN THE RIGHT PULMONARY ARTERIES

The course and relations of the right pulmonary artery are very similar both in dog and in man.

In each it commences on the left of the median plane, caudal and slightly to the left of the arch of aorta - the right artery, thus, being longer than the left. From its commencement it passes to the right nearly horizontally in man, but caudally and to the right in dog, dorsal to the first part of the aorta and cephalic vena cava before entering the hilum. In this part of its course it passes caudal to the arches of aorta and vena azygos. In man it is related dorsally to the oesophagus and to the right main bronchus below the "eparterial" branch, but in dog it is related dorsally to the caudal end of the trachea, the right main bronchus at its origin and the proximal end of the right apical lobe bronchus. In both it runs along the cephalic border of the left atrium. As it enters the lung, it lies ventral to the bronchus intermedius in man, and the corresponding part of the stem bronchus in dog, i.e., caudal to the "eparterial" bronchus.

Before entering the hilum it divides, in man, into the "truncus superior (upper division)" and "truncus inferior (lower division)" of Appleton ("ascending" and "descending" trunks of Ewart respectively). The corresponding division in dog results in the origin of the cephalic artery of the apical lobe and the continuation of the pulmonary artery. The cephalic artery, therefore, corresponds to the "truncus superior", and the continuation of the pulmonary artery in dog

to the "truncus inferior" in man.*

The division of the right pulmonary artery into the two trunks, in man, takes place dorsal to the right margin of the superior vena cava (Appleton quoting Hovelacque et al., 1937; and Brock, 1942). In dog the corresponding division takes place either dorsal to the right margin, or the middle, of the vena cava.

Before division, the pulmonary artery lies immediately cephalic to the superior pulmonary vein in man and cephalic to the corresponding vein in dog, the vein lying in a slightly ventral plane.

In man the anterior descending vein (internal ascending vein of Ewart) joins the superior pulmonary vein "opposite the anterior lip of the lung in the hilum" (Appleton) and "in front of the termination of the main arterial trunk" (Ewart). The corresponding vein in the dog, vein D_1 - D_2 or D_1 - d_2 -T, crosses the cephalic artery either at or a little inside or sometimes outside the lobar hilum.

The truncus inferior, in man, passes caudally and laterally, to lie between the upper lobe bronchus and the main bronchus, and is crossed by the superior pulmonary vein. The corresponding part of the pulmonary artery in dog has the same relations.

* The disproportion between the relative sizes of the cephalic artery and the parent pulmonary artery in dog does not permit calling them trunks or divisions - and thus giving them an equal status, when the former distinctly appears as a side branch of the latter.

In man the corresponding vessels, being almost of equal size, calling them trunks is suitable. But Ewart points out that the descending division may be regarded as the continuation of the main artery. In dog, however, there can be no doubt in the corresponding part being the continuation.

In man, as pointed out by Appleton, the artery "is not readily distinguishable from the superior pulmonary vein" (as emphasised by Brock, 1940-41), on account of a strong fascial connection between the pericardium and the sheath of the pulmonary artery". The same remarks are applicable to dog.

The artery then lies in the depth of the interlobar fissure, against the pleura, both in man and in dog, and it gradually comes to lie lateral to the main bronchus, running parallel to it.

In man the truncus inferior supplies the middle and the inferior lobes and, in addition, it supplies a variable portion of the upper lobe (Appleton). The corresponding part of the dog's pulmonary artery supplies corresponding parts, i.e., the cardiac lobe (equivalent to the human middle lobe), the diaphragmatic and the intermediate lobes (equivalent to the human lower lobe) and a variable part of the apical lobe (equivalent to the human upper lobe).

The corresponding arteries of man and of dog are tabulated below:-

<u>Man</u>	<u>Dog</u>
Truncus superior (Pectori-apical Trunk of Ewart; (Truncus anterior of Boyden and Scannell)	Cephalic artery
Truncus Inferior	Continuation of pulmonary artery, beyond the origin of cephalic artery
Artery to the middle lobe	Artery to the cardiac lobe
Artery to the lower lobe	Artery to the diaphragmatic and intermediate lobes
Posterior ascending artery of Appleton (inferior axillary artery of Ewart)	Caudal artery

The truncus superior, in man, enters the lung ventral to the right bronchus, whereas in the dog the corresponding artery - the cephalic artery - lies ventro-cephalic to the transverse part of the apical lobe bronchus. In man its upper margin "approximates to the level of the junction of the upper lobar bronchus with the main bronchus" (Appleton). In dog it is the most cephalic of the hilar structures. Only a small lateral part of it in the dog is covered by the pleura before its entry into the hilum, the medial part, as in man, being dorsal to the vena cava.

"The posterior ascending artery..... arises from the postero-superior aspect of the truncus inferior..... some $\frac{3}{4}$ inch from its commencement. At its origin it is below the pectoral bronchus....." (Appleton). The corresponding caudal artery of the right apical lobe of dog originates from one-fifth to about three-fifths of an inch from the origin of the cephalic artery, and lies caudal to the lobar bronchus.

The artery to the middle lobe, in man, originates a little lower than the corresponding bronchus (Ewart). In the dog the artery to the cardiac lobe arises either opposite or slightly cephalic to the bronchus. However, in man, this artery is usually represented by two arteries.

The artery to the lower lobe in man lies antro-lateral to the main bronchus at the depth of the fissure, whereas in dog it is constantly lateral to the main bronchus.

COMPARISON BETWEEN THE ARTERIES OF THE RIGHT
UPPER LOBE OF HUMAN, AND THE RIGHT APICAL
LOBE OF DOG'S LUNG

Truncus Superior of Man and the Cephalic
Artery of Dog, and Their Branches

The morphologically homologous areas between the right upper lobe of human lung and the corresponding lobe of dog's lung have been indicated in Table 32 (item I (1)). Therefore, the corresponding arteries supplying these identical areas are:-

<u>Dog</u>	<u>Man</u>
Artery D ₁ (Supplying segment D ₁)	Apical segmental artery ("A ₁ " of Boyden and Scannell; "apical" of Appleton)
Continuation of the lobar artery after giving off artery D ₁ (supplying segments D ₂ +V ₁ +V ₂ +T)	Anterior segmental artery ("A ₂ " of Boyden and Scannell; "pectoral" of Appleton)
Caudal artery (supplying P segment)	Posterior segmental artery ("A ₃ " of Boyden and Scannell; "posterior" of Appleton - The posterior segment has a "varied arterial supply" according to Appleton)

It has been shown that the truncus superior (or the Truncus Anterior of Boyden and Scannell) of the right human pulmonary artery corresponds to the cephalic artery of the right apical lobe of dog.

According to Appleton it divides exclusively into the corresponding "apical" and "pectoral" arteries in 30 per cent specimens (his Type 1), and into "apical" (giving rise to the recurrent artery, which may arise from its posterior branch, the posterior apical artery) and "pectoral" arteries in 38 per

cent specimens (his Type 2).

Boyden and Scannell's corresponding figures are 10 per cent and 56 per cent respectively.

In dog, in 12 out of 18 specimens, the corresponding division of the cephalic artery results in artery D_1 and the continuation of the parent artery. In the remaining 6 specimens, artery D_1 was the second branch to arise, the first being the recurrent artery in 4, and artery V_1 in 2 specimens.

Thus in dog, the majority of the specimens, 12 out of 18, in which the first artery to arise was D_1 , the arrangement corresponds to Appleton's 38 per cent specimens, and Boyden and Scannell's 56 per cent specimens mentioned above.

The findings discussed above are summarised in Table 43.

It is clear that exclusive division of the lobar artery into artery D_1 and the continuation of lobar artery is more common in the dog; and that the recurrent artery in dog never arises from artery D_1 (corresponding to apical artery of human lung) as far as the 18 specimens studied are concerned.

In all types of variations of arterial pattern, Appleton found recurrent artery in 88 per cent, and Boyden and Scannell in 58 per cent specimens of human lung arising from the apical artery (superior trunk of Boyden and Scannell), whereas in dog only 4 specimens had a recurrent artery (the caudal artery) arising from the lobar artery as its first branch.

Appleton's remaining three types, Types 3, 4 and 5 (18%, 8% and 6%), Boyden and Scannell's "trifurcation" type (18%) and their type in which the anterior trunk splits into superior and inferior trunks (14%), were not found in dog and, therefore,

have not been dealt with.

Table 4-3

COMPARISON BETWEEN THE TRUNCUS SUPERIOR OF MAN
AND THE CEPHALIC ARTERY OF DOG

Artery (The names of the corresponding arteries of dog are given in parenthesis)	M a n		D o g
	Appleton (50 Specimens)	Boyden & Scannell (50 Specimens)	(18 Specimens)
Truncus superior (cephalic artery) divides exclusively into apical (D_1) and pectoral (continuation of the lobar artery)	30% (Type 1)	10%	67% (12 specimens)
Truncus superior divides into apical (D_1), giving off recurrent artery (caudal) and pectoral (continuation of lobar artery)	38% (Type 2)	56%	0%
Recurrent artery (caudal) originates from truncus superior (lobar artery) as the first branch	0% (none mentioned)	0% (none mentioned)	22% (4 specimens)
Artery V_1 of dog originates from the lobar artery as the first branch (applicable only to dog)	-	-	11% (2 specimens)

Branches of Truncus Inferior of Man and of the Corresponding Part of the Right Pulmonary Artery of Dog

Branches of the truncus inferior supplying the human upper lobe have been called the "ascending" arteries by Appleton as well as by Boyden and Scannell. They have been classified into the "posterior ascending" and "pectoral ascending" by the former, and have been referred to as "artery to the posterior segment" and "artery to the anterior segment" respectively by the latter authors. These

arteries supply portions of the posterior or the anterior segments of man.

In dog also there are arteries which correspond in their origins and distribution to the "ascending" arteries but considering their directions they cannot be defined as "ascending". These arteries are the caudal artery, and artery V_1 when it originates independently from the pulmonary artery.

The caudal artery (described on page 15/) originates from the part of pulmonary artery that corresponds to "truncus inferior". It is distributed to P segment, which corresponds to the posterior segment of the human right upper lobe, and thus represents the "posterior ascending" artery of human lung.

Artery V_1 was found to originate independently from the pulmonary artery just distal to the origin of cephalic artery in 2 lobes (page 153). As described already it passed ventro-medial to the lobar bronchus, which corresponds to the pectoral bronchus of man. It thus corresponds in these two lobes to the pectoral ascending artery.

The findings of Appleton, and Boyden and Scannell, concerning the ascending arteries, are compared to those of the corresponding arteries in dog in Table 44. given below.

It can be seen from the Table that the writer's figures in dog are nearer Boyden and Scannell's figures.

Boyden and Scannell found the origin of ascending arteries in common with the artery of the apical segment of the lower lobe in 14 per cent, and in common with an artery of the middle lobe in 6 per cent. In 14 per cent they found the ascending posterior artery associated with the ascending anterior segmental artery. No such arrangements were found in dog.

Table 4-4

COMPARISON BETWEEN THE ASCENDING ARTERIES IN MAN
AND THE CORRESPONDING ARTERIES (CAUDAL AND V_1 -
described above) IN DOG

	M a n		D o g
	Appleton (50 lungs)	Boyden & Scannell (50 lungs)	(18 lungs)
Present in	95%	92%	89% (16 specimens)
Represented by:-			
1 artery	56%	74%	77.8% (14 specimens)
2 arteries	34%	18%	11% (2 specimens)
3 "	6%	0%	0%
Absent in	5%	8%	11% (2 specimens)

According to Appleton, the commonest pattern of the ascending arteries is when posterior ascending artery alone is present. This is true for the dog in which the caudal artery alone was present in 13 specimens out of 18 (14, if a specimen in which the caudal artery was represented by two arteries be included).

According to him, the presence of both posterior and pectoral arteries is less common. The same is true for dog as only in two lobes, both caudal artery and artery V_1 were present.

Appleton found the pectoral ascending artery in 48 per cent specimens. In dog the corresponding artery of V_1 was present in 11 per cent of 18 specimens.

The posterior ascending artery was found by him in 78 per cent specimens. In dog the corresponding caudal artery was present in 83.3 per cent (15 out of 18 specimens), including

the specimen in which the caudal artery was represented by two arteries. As mentioned by Appleton, there may be two posterior ascending arteries in the human lung too.

The Segmental Arteries

The Apical Artery of Man and Artery D₁ of Dog

Artery D₁, unlike the apical artery, is not accessible under the pleura on ventral approach to the hilum. In all specimens, however, its origin was close to the hilum. The apical artery from its origin proceeds obliquely in a lateral and cephalic direction. The corresponding artery D₁ of dog is directed cephalically and dorsally.

The apical artery ("A₁" of Boyden and Scannell) is always a branch of truncus anterior. So is artery D₁ always a branch of the corresponding cephalic artery. In man the apical artery divides according to Boyden and Scannell into anterior ramus A_{1b} (anterior apical branch of Appleton) and apical ramus A_{1a} (posterior apical branch of Appleton) in 72 per cent of 50 specimens. In the remaining 28 per cent it comprises ramus A_{1a} only. No such arrangements were recognised in dog.

Since no branch corresponding to the axillary branch of the apical bronchus is recognisable in dog, no artery corresponding to the axillary branch of the apical artery exists.

The apical artery in the human lung assists in the supply of the adjacent segments. Appleton found it to supply the pectoral segment in 4 per cent specimens. In another 4 per cent specimens it supplied the posterior segment by branches

in addition to the recurrent arteries. In no specimen did artery D_1 of dog supply the adjacent segments.

The above comparison shows that, apart from the identical origins of the apical artery of man and artery D_1 of dog, no other points of resemblance exist between them.

The Pectoral (Anterior Segmental) Artery of Man,
and the Cephalic Artery Beyond the Origin of
Artery D_1 of Dog

The pectoral artery of the human upper lobe corresponds to the cephalic artery of the dog's apical lobe beyond the origin of artery D_1 .

According to Appleton, the pectoral artery is readily seen on anterior approach to the root. In the dog the corresponding artery, the cephalic artery beyond the origin of artery D_1 , commences just within the hilum, so that it is inaccessible at or outside the hilum.

The pectoral artery in human lung runs close to the mediastinal surface and separates it from the pectoral bronchus (Appleton). The corresponding cephalic artery in dog runs, at first, medial to the lobar stem bronchus (which corresponds to the pectoral bronchus) and then, as has been described before, crosses over to the lateral side of it by passing through one of the proximal dorsal interbronchial spaces.

The pectoral artery divides into a "pectoral axillary" and a "pectoral terminal" branch (Appleton). The corresponding division of the dog's artery results in artery V_1 and the continuation of the lobar artery. The pectoral axillary artery in man supplies the pectoral axillary subsegment. Artery V_1 in dog supplies segment V_1 . The morphological

resemblance between the axillary pectoral subsegment and segment V_1 has already been pointed out on page 280. Thus the pectoral axillary artery corresponds to artery V_1 and the "pectoral terminal" corresponds to the continuation of the cephalic or lobar artery beyond the origin of artery V_1 .

The writer has failed to see any further resemblance between the arterial patterns beyond the origins of the pectoral axillary artery in man and artery V_1 in dog.

The Pectoral Axillary Artery and Artery V_1

The pectoral axillary artery was found by Appleton in 96 per cent specimens.

In dog artery V_1 was found to arise from the cephalic artery in 16 out of 18 specimens (89%). In the remaining 2 lobes (11%) it was a branch of the pulmonary artery and thus represented the "ascending pectoral" artery of man.

According to Appleton the pectoral axillary artery supplied the whole of the pectoral axillary subsegment in 42 per cent specimens. In 58 per cent it supplied only a part of the subsegment, its place being taken by the pectoral ascending artery. In dog artery V_1 supplied the whole of segment V_1 in all the 18 specimens, but in 16 out of these specimens, as stated above, it originated from the cephalic artery, and in the remaining 2 specimens it represented the ascending pectoral artery.

The pectoral axillary artery, according to Appleton, passes above the pectoral bronchus. In dog artery V_1 passed dorsal to the lobar bronchus, corresponding to the pectoral bronchus, only in 5 specimens, and in these it passed through interbronchial space D_1 - D_2 (see the description of the course

of artery V_1 on page 153).

In 14 per cent of his specimens, Appleton found a branch of one of the branches of pectoral axillary artery contributing to the supply of the apical segment and of a part or whole of the posterior segment. No such arrangement was found in dog.

Arteries of the Posterior Segment of Man
and of the P-Segment of Dog

The variability of the arterial supply of the posterior segment in man is obvious from the findings of Appleton and of Boyden and Scannell, given separately in Table 45.

It is difficult to consolidate their figures together. Therefore, the corresponding figures of dog, for comparison, are indicated separately in the Table against their respective figures.

It is clear that in man the posterior segmental artery cannot be considered a constant entity, which, as a single stem, is present only in 30 per cent specimens according to Boyden and Scannell as against 88.9 per cent in dog. Two or more arteries occur with a much greater frequency in man (70%) than in dog (11.0%).

According to Appleton, in 14 per cent specimens arteries come from the pectoral, the apical and the middle lobe arteries. No identical examples were encountered in dog.

Thus the arterial supply of P-segment is less variable in dog than that of the corresponding posterior segment in man.

The Recurrent Arteries

In man, according to Appleton, the recurrent artery is derived from truncus superior or apical or posterior apical artery, and it generally passes backwards "above" (cephalic) to the upper lobe bronchus. In dog it was derived, in all

Table 4-5

COMPARISON BETWEEN ARTERIAL SUPPLY OF THE POSTERIOR
SEGMENT OF MAN AND P-SEGMENT OF DOG

Arterial Supply of the Posterior Segment or the P-segment	M A N Appleton's figures (50 lungs)	D O G (18 lungs)
(Terminology for dog given in parenthesis)		
By Posterior ascending (caudal) only	32%	77.8% (14 lobes*)
By Posterior ascending + recurrent (caudal + recurrent)	32%	5.6% (1 lobe)
By Recurrent (recurrent) only	22%	16.7% (3 lobes)
Other patterns - by branches from pectoral, apical, or middle lobe arteries	14%	0%
	Boyden & Scannell's figures (50 lungs)	
<u>By a single stem:-</u>	30%	88.9% (16 lobes)
Recurrent branch	18%	16.7% (3 lobes)
Direct branch of the interlobar portion of the pulmonary artery (caudal)	12%	72.2% (13 lobes)
By two or more independ- ent arteries of varying origins	70%	11.0% (2 lobes)

* Caudal artery represented by 2 arteries in one of the lobes

those four lobes in which it was present, from the cephalic
artery, and passed caudally dorsal to the bronchus.

Appleton's findings in man are compared to writer's findings in dog below:-

<u>Recurrent Artery</u>	<u>Man</u> (50 lungs)	<u>Dog</u> (18 lungs)
Present in	58%	22.22% (4 lobes)
Supplies the whole of posterior segment (P segment of dog)	40%	16.7% (3 lobes)
Supplies a part of posterior segment (P segment of dog)	18%	5.55% (1 lobe)

(A₁ and A₂ of Boyden and Hare respectively) arising "occasionally" from the pulmonary stem.

Appleton (1944) stated that it is "generally" supplied by two arteries.

Lindskog et al (1949) found a single trunk in 56 per cent and two separate arteries in 44 per cent (of 25 corrosion preparations). Liard (1950), quoted by Boyden and Hare, found two arteries in 56 per cent (of 50 specimens); and also found a third artery from medial basal artery in 4 per cent specimens.

Boyden and Hare (1951) found two arteries in 52 per cent (of 50 specimens).

In none of the 18 right cardiac lobes of dog was a double arterial supply found. Each lobe was supplied by a single artery.

Position of Lobar Arteries

According to Boyden and Hare, the middle lobe artery for the proximal one (if two are present), was found to be virtually at the level (22 per cent), or above the level (33 per cent), of the superior artery of lower lobe. If two middle lobe arteries, A₃ and A₄, were present, the middle lobe artery was found to be virtually at the level (22 per cent), or above the level (33 per cent), of the superior artery of lower lobe.

COMPARISON BETWEEN THE ARTERIES OF
RIGHT MIDDLE LOBE OF HUMAN, AND THE
RIGHT CARDIAC LOBE OF DOG'S LUNG.

Number of Lobar Arteries

Ewart has described a single artery for the middle lobe.

Herrnheisser and Kubat (1936), quoted by Boyden and Hamre, found the "costal ramus or the axillary branch of it" (A₄ and A_{4a} of Boyden and Hamre respectively) arising "occasionally" from the pulmonary stem.

Appleton (1944) stated that it is "generally" supplied by two arteries.

Lindskog et al (1949) found a single trunk in 56 per cent and two separate arteries in 44 per cent (of 25 corrosion preparations). Liard (1950), quoted by Boyden and Hamre, found two arteries in 56 per cent (of 50 specimens); and also found a third artery from medial basal artery in 4 per cent specimens.

Boyden and Hamre (1951) found two arteries in 52 per cent (of 50 specimens).

In none of the 18 right cardiac lobes of dog was a double arterial supply found. Each lobe was supplied by a single artery.

Position of Lobar Arteries

According to Boyden and Hamre, the middle lobe artery "or the proximal one (if two are present), was found to be virtually at the level (22 per cent), or above the level (26 per cent), of the superior artery of lower lobe, A₆, or its upper ramus, A_{6a}+b..... If two middle lobe arteries are present

the distal one is usually below but may be at the level of A₆."

The artery in dog, which corresponds to A₆ of man, is D₁ of diaphragmatic lobe. In all the lungs of dog the artery to the cardiac lobe originated proximal to artery D₁ of the diaphragmatic lobe; the distance between them varying from 5-16 mm. with an average of 11 mm.

In man Boyden and Hamre found the ascending arteries to the upper lobe (their A_{2a} or A₃) occur below the level of the highest middle lobe artery in 12 per cent, and at the level in 40 per cent specimens. In dog in no specimen did the caudal artery of apical lobe (corresponding to the ascending arteries of man) arise distal to the middle lobe artery. As against the figure of 40 per cent in man, only in 11 per cent (2 out of 18 specimens), and in an additional specimen (E 35) illustrated in Fig. 37, did the caudal artery arise at the level of the cardiac lobe artery. The distance between the origins of the caudal artery and the artery of the cardiac lobe, measured in 15 specimens in which the caudal artery was present, varied from 0 to 7.5 mm. with an average of 4.5 mm.

Thus the artery to the cardiac lobe in dog, as compared to the middle lobe artery in man, is situated relatively much more cephalically in relation to artery D₁ (corresponding to artery A₆ of man), and relatively more caudally in relation to the caudal artery of the apical lobe (corresponding to the ascending artery of man).

The Segmental Arteries

The morphologically identical areas of the middle lobe of man and the right cardiac lobe of dog have been pointed out in Table 32. Thus the corresponding arteries are:-

Dog

Artery P_1 (supplying segment P_1)

Continuation of the lobar artery, beyond the origin of artery P_1 (supplying the remaining lobe)

Man

Artery to the lateral segment ("A₄" of Boyden and Hamre)

Artery to the medial segment ("A₅" of Boyden and Hamre)

Boyden and Hamre did not find the arterial pattern to correspond to the bronchial pattern in all human middle lobes. In 22 per cent (of 50 specimens) a single lobar artery divided into segmental arteries "A₄" and "A₅". In 14 per cent specimens they found arteries A₄ and A₅ arising separately from the pulmonary artery. These 36 per cent specimens (22% + 14%) conform to what they have referred to as the "conventional" pattern. Only in "eight-ninths" of these specimens they found the arteries correspond to the bronchi, i.e., in 32 per cent. But in all specimens of the cardiac lobes of dog the arrangement of artery P_1 , and the continuation of the lobar artery beyond the origin of P_1 , corresponded exactly to the bronchial pattern.

Thus, whereas in man Boyden and Hamre found the arterial pattern correspond to the bronchial pattern in 32 per cent (of 50 specimens), in dog the corresponding figure is 100 per cent (of 18 specimens). Two differences, however, still exist:-

1. In the human middle lobe arteries A₄ and A₅ are the products of a bifurcation, but artery P_1 of dog, corresponding to artery A₄ of man, is a side branch of the lobar artery. The artery in dog, which corresponds to artery A₅, is the continuation of the lobar artery.
2. 32 per cent specimens of Boyden and Hamre, referred to above, include lobes, whose number has not been mentioned, in which the arteries to the two segments arise independently. No such lobes existed in the dog's specimens.

COMPARISON BETWEEN THE ARTERIES OF THE RIGHT LOWER
LOBE OF HUMAN, AND THE ARTERIES OF THE DIAPHRAGMATIC
AND INTERMEDIATE LOBES OF DOG'S LUNG

The morphologically similar areas of the corresponding ^{right} lower lobe of the human, and the/diaphragmatic and the intermediate lobes of dog have been indicated in Table 32. The corresponding arteries, therefore, are:-

<u>Man*</u>	<u>Dog</u>
Artery to lower lobe	Artery to the diaphragmatic and the intermediate lobes
Artery to apical segment (A ₆)	Artery D ₁
Artery to anterior basal segment (A ₈)	Artery V ₁
Artery to lateral basal segment (A ₉)	Artery V ₂
Artery to posterior basal segment (A ₁₀)	Arteries D ₂ [≠] and the continuation of lobar artery supplying T-segment
Artery to medial basal segment (A ₇)	Artery to intermediate lobe

* Ferry and Boyden's terminology is given in parenthesis.

≠ Artery D₂ corresponds to "lesser posterior horizontal" artery of Ewart.

According to Ferry and Boyden the artery to the lower lobe of human lung is the continuation of "pars interlobaris", i.e., the part between their "truncus anterior" (Truncus Superior) and the middle lobe artery. The corresponding "pars interlobaris" of dog's artery is continued into the common artery of the diaphragmatic and the intermediate lobes.

In man, according to them, the lobar artery "almost immediately gives off the artery to the superior segment (A₆) and then continues as the pars basalis, the trunk which supplies the basal segments". In dog the first artery to arise

from the artery, corresponding to the lower lobe artery, is the artery to the intermediate lobe (corresponding to the artery of the medial basal segment), and thus precedes artery D_1 (corresponding to the artery of the apical segment, " A_6 " of Ferry and Boyden) in nearly all the lobes (17 out of 18); in the 18th lobe the two arteries arose at the same level. A "pars basalis", therefore, does not exist in dog. If the continuation of the lobar artery in dog, beyond the origin of artery D_1 , be considered as pars basalis, then, whereas in man it supplies 4 basal segments, in dog it supplies the corresponding areas except the intermediate lobe.

Ferry and Boyden mention that if there be two middle lobe arteries, artery A_6 (of apical segment) may be situated between the two. Also artery A_6 may be represented by two arteries, each lying "below the corresponding middle lobe artery". This further complicates a comparison of the "pars basalis".

The Artery of the Superior Segment of Man
and Artery D_1 of Dog

The patterns of the rami of bronchus D_1 and artery D_1 were not studied in dog. It is, therefore, not possible to take into consideration the details of the corresponding artery, A_6 , given by Ferry and Boyden.

A single artery, according to them, supplies the superior segment in 80 per cent specimens. The corresponding figure for dog is 88.9 per cent (16 out of 18 lobes). In 16 per cent they found two, and in 4 per cent, three separate arteries supplying the segment. In dog, in 11 per cent specimens (2 out of 18 lobes) segment D_1 had a minute additional artery, situated distal to the main segmental artery. In no specimen

were three arteries found.

In 10 per cent specimens Ferry and Boyden found a "displaced" ascending artery to upper lobe arising from artery A₆. No such instance was found in dog.

The Artery of the Medial Basal Segment of Man
and of the Intermediate Lobe of Dog

Ferry and Boyden have correlated the arterial pattern of arteries "A₇" and "A₈" (supplying the medial and the anterior basal segments respectively) with their 4 "types" of medial basal bronchus, "B₇", classified according to its origin and area of distribution. No such typing of the corresponding intermediate lobe bronchus is necessary because its position, as well as its area of supply, the intermediate lobe, are constant.

Disregarding these 4 "types" their findings were:-

Medial basal artery as the first branch of basal artery (pars basalis)	38%
--	-----

Common stem of medial basal and the anterior basal ("A ₇₊₈ ") as the first branch of basal artery (pars basalis)	18%
--	-----

	—
	56%
	—

Their remaining 44 per cent specimens comprise complex patterns. Except 6 per cent of these (3 specimens), they comprise specimens in which the two main rami of the artery, A_{7a} and A_{7b}, originate from different sources.

The artery of the intermediate lobe of the dog, however, as explained already, cannot be described to arise from "pars basalis" as the latter does not exist. In 100 per cent specimens it was a branch of the main pulmonary artery. In

94.4 per cent (17 specimens) it preceded the origin of artery D_1 , and in 5.6 per cent (1 specimen) its origin was opposite the origin of D_1 .

In man the medial basal segmental artery divides to supply the two main rami of the medial basal bronchus. In dog, the corresponding artery runs through the intermediate lobe as a central stem accompanying the lobar bronchus, and they both give off branches in a serial manner.

The Artery of the Anterior Basal Segment of Man and Artery V_1 of Dog

The findings of Ferry and Boyden with regard to artery of the anterior basal segment, " A_8 ", are:-

Origin as a single stem	48%
Origin with " A_7 " or " A_7a "	16%
Origin with " A_9 " (artery of lateral basal segment)	12%
Two separate trunks from the basal artery, or A_7 or A_9	24%

In dog artery V_1 was a single artery in all the 18 lobes, except in 1 lobe in which the segment was supplied by an additional minute artery of a negligible size (Table 18, Specimen M16). Artery V_1 was a branch of the lobar artery in 100 per cent specimens.

The Arteries of the Lateral Basal and the Posterior Basal Segments of Man, and the Corresponding Arteries - V_2 and the Continuation of the Lobar Artery (beyond the origin of artery V_2) of Dog

The basal artery in man, according to Ferry and Boyden, terminates by bifurcating into the arteries of the lateral and the posterior basal segments (" A_9 " and " A_{10} " respectively) in 44 per cent specimens.

Of the remaining 56 per cent, "in 18 per cent A_9 is split, its two rami arising separately from the basal artery or in common with branches to other segments. In 30 per cent, A_9 is atypically associated with A_8 , A_{7+8} , A^* , AX^* ; and in 8 per cent the branches of A_9 and A_{10} are mixed". In dog, artery V_2 , corresponding to the lateral basal segmental artery (A_9 of Ferry and Boyden), was the sole supply of segment V_2 in 61 per cent specimens (11 out of 18 lobes). In the remaining 39 per cent specimens (7 out of 18 lobes) an additional independent artery, of a negligible size, supplied the segment. Practically in all the 18 lobes segment V_2 may thus be considered to be supplied by a single artery, which was a branch of the main lobar artery. In none of the specimens was the artery "split" or "associated" with any other artery.

The posterior basal segment has been shown in Table 32 to correspond to segments $D_2 + T$. The difficulty of comparing the arterial supply of these two areas is obvious. Ferry and Boyden have disregarded the "dorsal" rami ("subsuperior" arteries) "since they are variable in origin as (are) the corresponding bronchi" (their B^* and BX^* bronchi). The bronchi in the dog corresponding to B^* and BX^* are bronchi D_2 , D_3 If these, too, be disregarded, then it may be stated that, whereas in man the posterior basal segment is supplied by artery A_{10} of Ferry and Boyden, a product of bifurcation of the basal artery, in dog the corresponding area, the T-segment (having disregarded areas D_2 , D_3 ), is supplied by the continuation of the lobar artery.

The Arteries of the Human "Subsuperior Zones (A* and AX*)" of Ferry and Boyden, and the Corresponding Arteries D₂, D₃ of Dog

In view of the extreme variability of the bronchi of these areas in man as well as in dog, and a very variable arterial supply in both, a comparison is not practicable. This may be explained to be due to a more cephalic position of the bronchi in dog as compared to its position in man. Both in man and dog the left bronchus and the aorta are its dorsal relations. These relations, therefore, are similar.

In the root of the lung, the artery is related ventrally to the superior pulmonary vein in man. In dog, the artery to be related to the vein of the left lung. This is a common vein out of 18. In the remaining 5 specimens of the specimen to the common vein formed by the union of the left bronchus and the left cardiac vein. The artery, which depends to the superior pulmonary vein in man.

The chief difference between the two species is in the manner in which the bronchi are arranged. In man branches to the dorsal part of the lung and the cephalic parts of the area of the arch. In dog the part of the artery called the subpulmonary part, which is the dorsal part of the artery, is the part of the artery called the apical and the cardiac part. The part of the artery, and some dogs the dorsal part of the arch of the artery.

Both in man and dog the corresponding dorsal, the cephalic lobe of dog.

COMPARISON BETWEEN THE LEFT PULMONARY ARTERIES

The left pulmonary artery of man, from its origin, runs in a dorso-lateral and slightly cephalic direction before arching over the left upper lobe bronchus. In dog it immediately runs dorso-laterally and cephalically so that the arched appearance is not so well marked. This may be explained to be due to a more cephalic position of the heart in dog as compared to its position in man. Both in man and in dog the left bronchus and the aorta are its dorsal relations. Their courses, therefore, are similar.

In the root of the lung, the artery is related ventrally to the superior pulmonary vein in man. In dog it was found to be related to the vein of the left apical lobe in 15 specimens out of 18. In the remaining 3 specimens it was related to the common vein formed by the early union of the left apical lobe vein and the left cardiac lobe vein. This common vein corresponds to the superior pulmonary vein of human lung.

The chief difference between the two arteries lies in the manner in which the branches are arranged on the pulmonary stems. In man branches to the upper lobe arise from the ventral and the cephalic parts of the arch of the artery, as well as from the part of the artery called the interlobar part, which is the dorsal part of the artery beyond the arch. In dog branches to the apical and the cardiac lobe arise only from the dorsal part of the artery, and none from the ventral and the cephalic parts of the arch of the artery.

Both in the man and in dog the main stem continues into the corresponding lobes, the lower lobe of man and the diaphragmatic lobe of dog.

COMPARISON BETWEEN THE ARTERIES OF LEFT
UPPER LOBE OF HUMAN, AND THE LEFT APICAL
AND CARDIAC LOBES OF DOG'S LUNG

It has been shown before that the left upper lobe (upper division) of human lung corresponds morphologically to left apical, and the lingula to the cardiac lobe of dog, and that at segmental level morphological homology only exists between segment D₁ of the apical lobe of dog and the posterior segment of the upper human lobe. The difficulty in determining homology between the remaining areas makes a comparison of the arteries of these areas impracticable. Therefore, it is only possible to restrict the comparison to the arteries of the following corresponding areas:-

<u>Man</u>	<u>Dog</u>
1. Upper lobe (upper division)	1. Left apical lobe
Posterior Segment	Segment D ₁
2. Upper lobe (lingula)	2. Left cardiac lobe

In man the upper division of the left upper lobe does not possess a single artery corresponding to the lobar artery of the left apical lobe of dog. Instead it is supplied by a variable number of arteries.

The arteries to the two main parts of upper lobe of man are usually described together. They arise, as stated already, from the ventral and the cephalic parts of the arch of the pulmonary artery, and in addition from its (dorsal) interlobar part. In dog they arise only from the dorsal part of the pulmonary artery.

Number of Arteries

The number of arteries supplying the left upper lobe vary according to different authors. Ewart mentions 3 to 4, Kent and Blades (1942) 4 to 7, Overholt and Langer (1949) 4 to 6, and Boyden and Hartmann (1946) 4 to 8. Their frequency distribution in human lungs, given by Boyden and Hartmann, is compared with that of the lungs of dog in Table 46.

Table 46

Arteries of Left Upper Lobe of Human (or Left Apical and Cardiac Lobes in Dog)	Man (Boyden and Hartmann - 50 lungs)	Dog (18 lungs)
Range	4 to 8	1 to 3
1 artery in each specimen	-	5.5% (common artery for the apical and the cardiac lobe)
2 arteries in " " "	-	77.8% (one each for the apical and the cardiac lobe)
3 " " " "	-	16.7% (two for apical and one for cardiac lobe)
4 " " " "	18%	-
5 " " " "	40%	-
6 " " " "	28%	-
7 " " " "	12%	-
8 " " " "	2%	-

Artery of the Posterior Segment of Left Human Upper Lobe ("A₃" of Boyden and Hartmann), and Artery D₁ of Left Apical Lobe of Dog's Lung

In 3 specimens only was artery D₁ of dog an independent branch of left pulmonary artery. In one specimen it was a branch of the artery of the cardiac lobe and in the remaining 14 specimens it was a branch of the lobar artery of the apical lobe.

The findings of Boyden and Hartmann, with regard to the corresponding artery A₃ are compared to the above findings in dog, in Table 47 given below.

Table 47

	<u>M a n</u> Boyden & Hartmann (50 lungs)	<u>D o g</u> (18 lungs)
(The terminology for dog given in parenthesis)		
Artery A ₃ (D ₁) arises independently from the pulmonary artery	54%	16.7% (3 lobes)
Artery A ₃ (D ₁) arises from the lingular artery (artery of the cardiac lobe)	0% (none mentioned)	5.5% (1 lobe)
Artery D ₁ of dog originates from the lobar artery of the apical lobe	Not applicable (Lobar artery as such does not exist in man)	77.8% (14 lobes)

In the remaing specimens of the human lung, not included above, artery A₃ originates from various other sources which cannot be compared with the dog's artery. These sources are summarised in Table II of Boyden and Hartmann's article.

Arteries of the Lingula of the Human ("A₄" and "A₅" of Boyden and Hartmann), and of the Left Cardiac Lobe of Dog's Lung

In 17 specimens, the artery of the cardiac lobe of the dog originated directly from the pulmonary artery, and in 1

specimen it had a common stem with the artery of the apical lobe. In all specimens its origin was from the interlobar (dorsal) part of the pulmonary artery. The findings in dog are compared to the findings in human lung, given by Boyden and Hartmann, in Table 4-8.

Table 4-8

(The terminology for dog is given in parenthesis)	<u>Man</u> (Boyden & Hartmann) Lingula (50 specimens)	<u>Dog</u> Left Cardiac Lobe (18 specimens)
Artery to cardiac lobe of dog originates in common with artery to apical lobe.	Not applicable, as artery to upper lobe (upper division) does not exist as a single stem.	5.5%
Lingular artery (artery to cardiac lobe) originates independently from the ventral part of the pulmonary artery.	8%	0%
Lingular artery (artery to cardiac lobe) originates independently from the interlobar part of the pulmonary artery.	36%	94.5%
Lingular artery originates in common with arterial branches to anterior segment-branches "A _{2a} " and "AX _{2a} " in their Table 2.	18%	Not applicable
Superior and inferior lingular arteries, "A ₄ " and "A ₅ ", originate separately from the interlobar part.	20%	Not applicable
Lingula (cardiac lobe) supplied by arteries from both sides of the lobe, ventral and dorsal.	22%	0%
One of the branches of lingular artery gives a branch to the medial basal segment of lower lobe	2%	Not applicable as "medial basal segment" does not exist

Artery of the Posterior Segment of Left Human Upper Lobe ("A₃" of Boyden and Hartmann), and Artery D₁ of Left Apical Lobe of Dog's Lung

In 3 specimens only was artery D₁ of dog an independent branch of left pulmonary artery. In one specimen it was a branch of the artery of the cardiac lobe and in the remaining 14 specimens it was a branch of the lobar artery of the apical lobe.

The findings of Boyden and Hartmann, with regard to the corresponding artery A₃ are compared to the above findings in dog, in Table 47 given below.

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Artery A₃ (D₁) arises from the lingular artery (artery of the cardiac lobe)

Artery D₁ of dog originates from the lobar artery of the apical lobe

<u>M a n</u> Boyden & Hartmann (50 lungs)	<u>D o g</u> (18 lungs)
54%	16.7% (3 lobes)
0% (none mentioned)	5.5% (1 lobe)
Not applicable (Lobar artery as such does not exist in man)	77.8% (14 lobes)

In the remaing specimens of the human lung, not included above, artery A₃ originates from various other sources which cannot be compared with the dog's artery. These sources are summarised in Table II of Boyden and Hartmann's article.

Arteries of the Lingula of the Human ("A₄" and "A₅" of Boyden and Hartmann), and of the Left Cardiac Lobe of Dog's Lung

In 17 specimens, the artery of the cardiac lobe of the dog originated directly from the pulmonary artery, and in 1

Man

Dog

A₉

V₂

A₁₀

Arteries to D₂* and D₃, and the continuation of 3rd lobar artery supplying the T-segment.

* Artery D₂ corresponds to Lesser Posterior Horizontal artery of Ewart.

In one of his two specimens (Plate 2), Boyden has depicted two arteries of about equal size to B₆. In 3 out of 18 lobes the corresponding segment D₁ was supplied by 2 arteries, the additional artery being very small (Specimens M4, M16, E52, Table 23).

Homologue of artery A₇ of Boyden is not found in dog as no B₇ is represented in dog on the left side.

Kent and Blagden (1942), in *The Dog*, state: "From the pulmonary veins on each side. There is a large venous tributary from the middle lobe which enters the left auricle, and there is a small one which enters the right pulmonary vein."

Overholt and Langer (1949) describing the pulmonary veins on each side in their book "The Techniques of Pulmonary Resection". Serova (1950), in *1950*, state: "From the veins on each side,

Fleishmann (1950) studied only 7 right and 6 left lungs, and from the abstract of their paper it is evident that he found two pulmonary

COMPARISON BETWEEN THE MAIN PULMONARY VEINS
OF MAN AND OF DOG

Number of Pulmonary Veins in Human Lungs

Although reports of anomalous drainage of pulmonary veins abound in literature, few statistical studies of the abnormal number of pulmonary veins draining normally into the left atrium were found in literature.

Healey and Gibbon (1950) and Healey (1952) found Adachi's report the only one in literature.

Brantigan (1947) has reported a few cases he discovered on the operation table while performing pneumonectomies, but the total number of cases examined has not been mentioned.

Ewart describes two pulmonary veins on the right and two on the left side, the total number of specimens examined again are not mentioned. According to him, "Occasionally..... they leave the auricle in the shape of a single large trunk" on the left side.

Kent and Blades (1942), in 227 fresh lungs, found two pulmonary veins on each side. "Rarely", they state, "the venous tributary from the middle lobe enters directly into the left auricle, and thereby exists as a third right pulmonary vein."

Overholt and Langer (1949) describe two pulmonary veins on each side in their book "The Technique of Pulmonary Resection". Serova (1950), in 171 lungs, found two veins on each side.

Fleishmann (1950) studied only 7 right and 6 left lungs, and from the abstract of their account studied, it is clear that he found two pulmonary veins on each side.

The current text books (Cunningham's Text Book of Anatomy, 1951; Gray's Anatomy, 1949; and a few others consulted) describe two pulmonary veins on each side. Only the variations in their number are recognised.

The available figures are summarised in Tables 49 and 50

Table 49
COMMON PULMONARY VEINS IN HUMAN LUNGS

Author	Total No. of Specimens examined	No. of Specimens with Common Pulmonary Veins	
		Right	Left
Adachi (1933)	70 cadavers	6	5
	21 corrosion preparations	0	0
Brantigan (1947)	?	0	3
Healey & Gibbon (1950)	185	6 (out of 184 specimens)	46
*Healey (1952)	66	1	7
Total (Excluding Brantigan's figures)	342	13 (3.8%)	58 (17%)

* Report on 251 specimens - 185 of Healey & Gibbon, and 66 of Healey.

Number of Pulmonary Veins in Man Compared to the Number of Pulmonary Veins in Dog

The frequency of the number of pulmonary veins observed in 20 specimens of dog's lungs are compared to their frequency in human lungs, in Table 51.

Table 50

INCREASED NUMBER OF PULMONARY
VEINS IN HUMAN LUNGS
(3 veins on either side)

Author	Total No. of specimens examined	No. of Specimens with 3 veins	
		Right	Left
Adachi (1933)	131 cadavers for right and 70 for left lung	3	2 (out of 70 cadavers)
	19 corrosion preparations	0	0
Brantigan (1947)	?	2	None reported
Healey & Gibbon (1950)	185	3	0
Healey (1952)	66	1	0
<u>Total (excluding Brantigan's figures)</u>	401 right lungs	7	2
	340 left lungs	(1.75%)	(0.5%)

Thus, as Healey and Gibbon point out and as is recognised in Cunningham's Text Book of Anatomy, in the human lung a greater number of veins, three instead of the usual two, is more common on the right side, and a common pulmonary vein is commoner on the left side.

Number of Pulmonary Veins in Man Compared to the Number of Pulmonary Veins in Dog

The frequency of the number of pulmonary veins observed in 20 specimens of dogs' lungs are compared to their frequency in human lungs, in Table 51.

Table 5/

NUMBER OF PULMONARY VEINS
IN MAN AND IN DOG

<u>RIGHT SIDE</u>	<u>M a n</u> (Percentages from Tables and)	<u>D o g</u> (20 lungs)
1 vein (common pulmonary vein)	3.8%	0%
2 veins (normal arrangement in man)	94.45%*	25%
3 veins	1.75%	75%
<u>LEFT SIDE</u>		
1 vein	17%	0%
2 veins	82.5%*	50%
3 veins	0.5%	50%

* These percentages are not given in Tables 4-9 and 50. They have been calculated by subtracting other figures in the columns from 100.

Conclusions

No lung of dog possesses a single pulmonary vein.

In man two veins are found in a large majority of right and left lungs (94.45% and 82.5% respectively). In dog 3 veins are more common on the right (70%) but on the left side 2 veins and 3 veins are found with an equal frequency (50% each).

In dog, 25% of right lungs and 50% of left lungs have 2 veins, an arrangement which conforms to the normal arrangement in man.

In man the left lung shows a definite tendency to possess a lesser number of pulmonary veins, i.e., 1 vein instead of the usual number of 2 - 17% on left as against 3.8% on right side. The number of specimens studied in dog is small, but

in them too, the left lungs tend to possess a lesser number of veins, i.e., 2 veins instead of 3 - 50% on left as against 25% on left side.

Boyden (1945) and Boyden and Seannell (1948) have recognised three major veins in the upper lobe of right human lung. They are:-*

V₁ - Apical anterior vein.

V₂ - Inferior vein (described by Appletan as two separate veins but not recognised as a major vein).

V₃ - Posterior vein.

The Apical Anterior Vein - V₁

The apical anterior vein (vena subpleuro-mediastinalis of Herrnhelsser and Kuntz; anterior descending vein of Appletan; superficial inner ascending trunk of Hart) lies under the mediastinal pleura and opposite the space between segmental bronchi B₁ (apical) and B₂ (anterior), i.e., opposite "apicopectoral intersegmental plane" of Appletan (according to Fig. 16 of Appletan, and Fig. 3 plate 3 of Boyden and Seannell, reproduced in Figs. 68a and 68b). It drains both the apical and the anterior segments.

The corresponding plane in the dog is between segment B₁ (corresponding to apical segment in man) and the area composed of segments B₂+V₁+V₂+T (corresponding to anterior segment in man), and the vein that lies in this plane is either vein B₁-B₂ (present in 8 out of 18 specimens) or vein B₁-B₂-T (present in another 8 out of 18 specimens) (see page 37/38).

* It should be noted that veins V₁, V₂ and V₃ in man must not be confused with veins in dog. In man the letter V stands for Vein. This is where Boyden's terminology is likely to be confused with that of the writer for dog. In dog V stands for Ventrals.

COMPARISON BETWEEN THE VEINS OF THE RIGHT
UPPER LOBE OF HUMAN, AND RIGHT APICAL
LOBE OF DOG'S LUNG

Boyden (1945) and Boyden and Scannell (1948) have recognised three major veins in the upper lobe of right human lung. They are:-*

V₁ - Apical anterior vein.

V₂ - Inferior vein (described by Appleton as two separate veins but not recognised as a major vein).

V₃ - Posterior vein.

The Apical Anterior Vein - V₁

The apical anterior vein (vena subpleuro-mediastinalis of Herrnheisser and Kubat; anterior descending vein of Appleton; superficial inner ascending trunk of Ewart) lies under the mediastinal pleura and opposite the space between segmental bronchi B₁ (apical) and B₂ (anterior), i.e., opposite "apico-pectoral intersegmental plane" of Appleton (according to Fig.16 of Appleton, and Fig.C plate 3 of Boyden and Scannell, reproduced in Figs.68α and 68β). It drains both the apical and the anterior segments.

The corresponding plane in the dog is between segment D₁ (corresponding to apical segment in man) and the area composed of segments D₂+V₁+V₂+T (corresponding to anterior segment in man), and the vein that lies in this plane is either vein D₁-D₂ (present in 8 out of 18 specimens) or vein D₁-d₂-T (present in another 8 out of 18 specimens) (see page 187, 188).

* It should be noted that veins V₁, V₂ and V₃ in man must not be confused with veins in dog. In man the letter V stands for Vein. This is where Boyden's terminology is likely to be confused with that of the writer for dog. In dog letter V stands for Ventral.

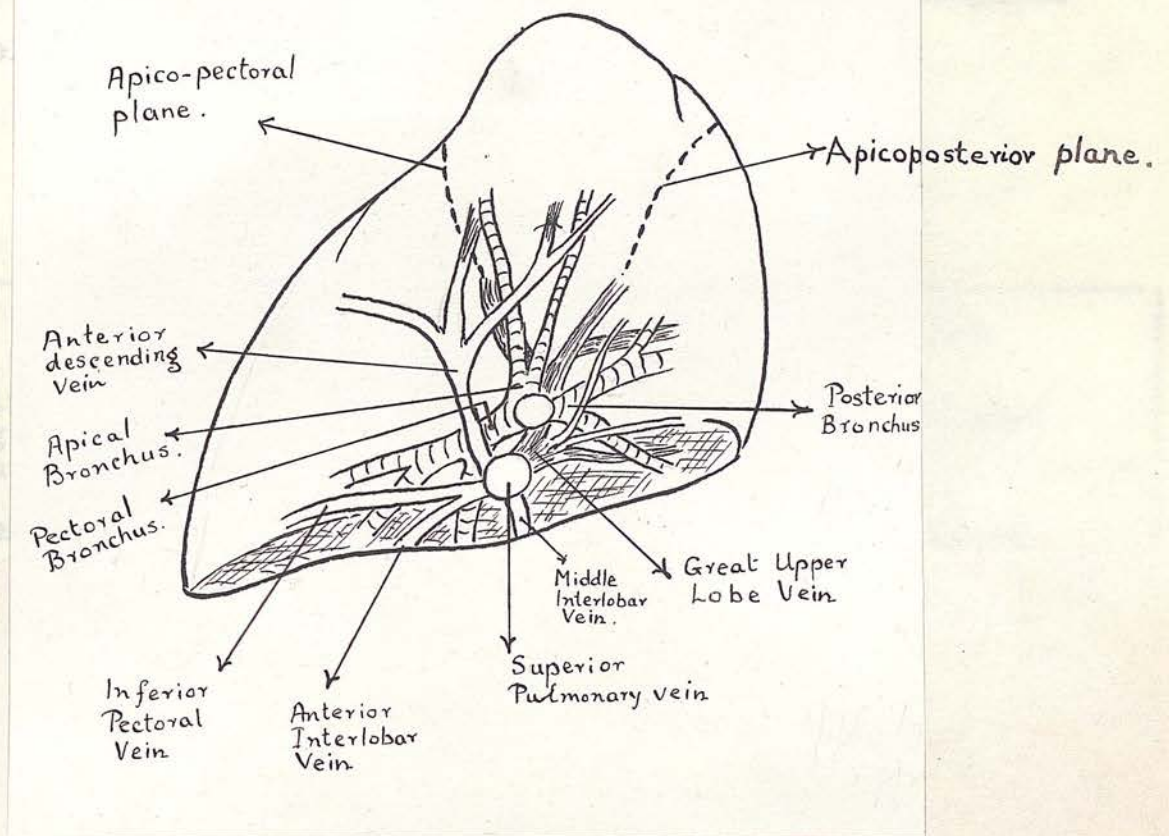


Fig. 68a.— Venous drainage of upper Lobe of Right Human Lung. (After Appleton, 1945 —. His Fig. 16).

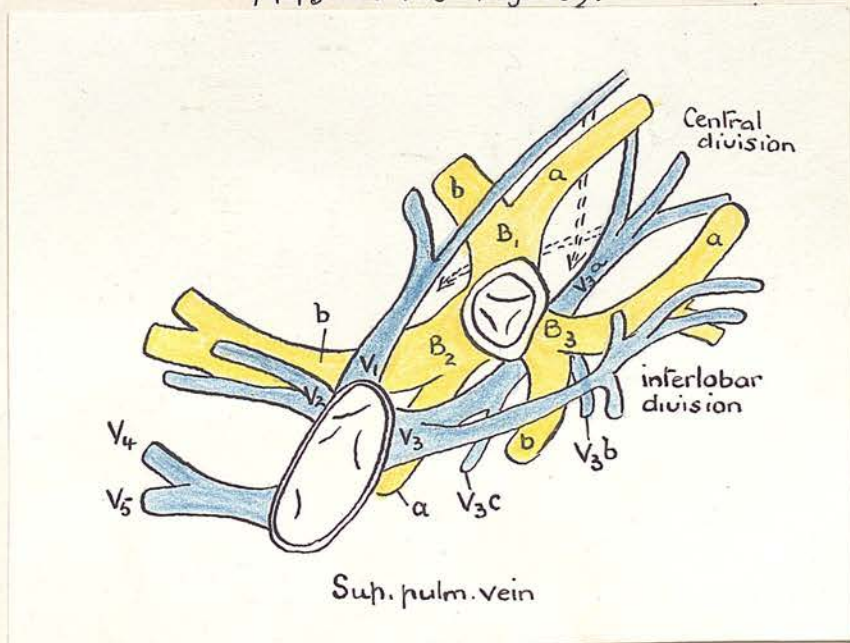


Fig. 68b.— Venous drainage of Upper Lobe of right human Lung. (After Boyden and Seannell—1948; their Plate 3, Fig. C.)

Thus vein V_1 in man corresponds either to vein D_1 - D_2 or to vein D_1 - d_2 -T in dog.

The above findings along with other details are compared in Table 52.

Table 52

THE APICAL ANTERIOR VEIN (V_1) OF MAN, AND
VEIN D_1 - D_2 (or D_1 - d_2 -T) OF DOG

(Terminology for dog given in parenthesis)	MAN Boyden & Scannell (50 lungs)	DOG (18 lungs)
Frequency	100%	88.9% (16 specimens)
Areas drained	Apical and anterior segments	D_1 and area $D_2+V_1+V_2+T$
Segments between which it lies	Between segments B_1 and B_2	Between segments D_1 and area $D_2+V_1+V_2+T$
Position (a) In relation to mediastinal pleura	Under mediastinal pleura in 56%	Not directly under mediastinal pleura - 88.9% (16 lobes). Absent in 11.1% (2 lobes)
(b) In relation to bronchus B_2 (lobar bronchus supplying area $D_2+V_1+V_2+T$)	"deep to B_2 ", i.e., lateral to it - 34% (before emptying into vein V_3)	Lateral to lobar bronchus only in 1 out of 18 lobes (vein D_1 - d_2 -T in specimen E50) - 5.5% (before it entered vein V_1 - V_2 which does not correspond to V_3).
Percentage in which it drains segment B_3 (posterior segment) by an aberrant branch VX_3a - their # 15, plate 8.	10%	No such aberrant branch present.

No resemblance exists between the tributaries of vein V_1 of man and vein D_1-D_2 (or vein D_1-d_2-T) of dog.

The Inferior Vein - V_2

This vein of the upper lobe of the right human lung, as an independent entity, has not been recognised by any authors other than Boyden and Scannell. It lies "inferior (caudal) to anterior segmental bronchus (B_2)" - (Boyden and Scannell).

The vein that lies in the corresponding position in relation to the lobar bronchus of dog (corresponding to bronchus B_2 of human lung) is the cephalic (lobar) vein of the right apical lobe, beyond the point of entry of vein D_1-D_2 (or D_1-d_2-T). But it is ventro-caudal to the bronchus instead of caudal. This difference can easily be explained by the "rotation" of the right apical lobe described already.

Boyden and Scannell have described five main patterns of this vein in man, but apart from the resemblance described in the preceding paragraphs and that both veins drain corresponding areas, no other points of resemblance can be seen between their five patterns and the various patterns found in dog.

The above findings, with some others, in man and dog are compared in Table 53.

The Posterior Vein - V_3 (Great upper lobar vein of Appleton)

According to Boyden and Scannell's "prevailing pattern" (50%) this vein, in the human lung, consists of two divisions - a "central" and an "interlobar".

The central division of vein V_3 is a "deep" vein which "emerges between B_{3b} (or B_3) and B_{2a} ". It can be seen then to pass ventral to the lobar bronchus in Appleton's Fig.16

and Boyden and Scannell's Fig.C, plate 3, reproduced in Figs.68a and 68b. This course strongly resembles the course followed by vein P-D₁, which emerges between bronchus P (corresponding to bronchus B₃ of man) and bronchus V₁ (corresponding to pectoral axillary bronchus - B_{2a} of Boyden and Scannell) (see Fig.40).

Table 53

THE INFERIOR VEIN (V₂) OF MAN, AND THE CEPHALIC (LOBAR) VEIN - BEYOND VEIN D₁-D₂ (or D₁-d₂-T) - IN DOG

(The terminology for dog is given in parenthesis)	MAN Boyden & Scannell (50 lungs)	DOG (18 lungs)
Present in	66%	100%
Areas drained	Anterior segment	Segments D ₂ +V ₁ +V ₂ +T
Relation to bronchus B ₂ (lobar bronchus supply- ing area D ₂ +V ₁ +V ₂ +T)	Inferior (caudal)	Ventro-caudal
One of the rami of vein V ₂ drains into:-		No corresponding examples exist in dog.
Vein V ₃	14%	
Vein V ₁	22%	
Middle lobe vein	10%	

The interlobar division is "a superficial vein draining the interlobar aspect of the lobe", and is joined by the central division. In dog the medial vein of P-segment drains an identical aspect (the fissural surface of P-segment) and joins vein P-D₁ (corresponding to the central division).

In man the central and the interlobar divisions join to

Table 54-

THE POSTERIOR VEIN (V_3) OF MAN AND THE CAUDAL VEIN OF DOG ϕ

(The terminology for dog is given in parenthesis)	MAN Boyden & Scannell (50 lungs)	DOG (18 lungs)
I. Frequency of the vein	100%	100%
II. Frequency of Main tributaries		
(a) Central division (vein P-D ₁)	82%*	100%
(b) Interlobar division (Medial vein of P-segment)	74%**	100%
III. Composition of the Vein		
(a) Made up of interlobar (medial vein of P-segment) and central (vein P-D ₁) divisions	50%	100%
(b) "Wholly central", i.e., represented by central division only (vein P-D ₁)	26%	0%
(c) "Wholly interlobar", i.e., represented by interlobar division only (medial vein of P-segment)	18%	0%

* 50% + 26% + 6%, according to items II 1 (1), II 1 (2) and II 1 (4) respectively, of Table 3 of Boyden & Scannell. (1948).

** 50% + 18% + 6%, according to items II 1 (1), II 1 (3) and II 1 (4) respectively, of Table 3 of Boyden & Scannell.

ϕ Quotations are of Boyden & Scannell.

form the posterior vein (V_3), and in dog the two corresponding veins join to form the caudal vein, which, however, in dog receives two additional tributaries P-V₁ and lateral. Thus the posterior vein in man and the caudal vein in dog correspond.

The above findings and some others are compared in Table 54.

Patterns III (a), III (b) and III (c) of the human lung in Table 54 correspond to the "intermediate", "arterial" and "venous" types respectively, described by Appleton. Thus in all dogs' specimens, only the intermediate type was found to exist, and the arterial and venous types were absent.

In 6% specimens of human lungs, Boyden and Scannell found the central and the interlobar divisions enter the superior pulmonary vein separately. No corresponding arrangement was found in dog.

Due to the major and minor fissures being complete in nearly all the lungs of dogs examined, few examples of communicating veins between adjacent lobes were found. Only two such examples, in which vein P_1 of right cardiac lobe drained into the caudal vein of right apical lobe, were encountered and have already been described (see page 196).

The only conclusion that may be drawn from the above comparison is that the tributaries of the caudal vein in dog are more constant (100% - items II(a), II(b) and III(a) in Table 54) than those of the posterior vein (V_3) in man.

It will be seen that, whereas in dog the caudal vein has been described to be formed by the union of 4 tributaries - veins $P-D_1$, $P-V_1$, the lateral and the medial, in man it has two main tributaries, the central and the interlobar divisions. The central division is identical to vein $P-D_1$ and the interlobar division to the medial vein of P-segment. The counterparts, in the human right upper lobe, of the other two tributaries in dog, have not been recognised.

Frequency (61%) than does the corresponding middle lobe vein of the human lung (4%).

It is also concluded that a lower mental level is impracticable.

COMPARISON BETWEEN THE VEINS OF RIGHT MIDDLE LOBE
OF HUMAN, AND RIGHT CARDIAC LOBE OF DOG'S LUNG

It has been stated before that the lateral segment of the middle lobe of human lung corresponds to segment P₁ of the cardiac lobe of dog's lung, and that the medial segment corresponds to area comprising segments P₂, A₁, A₂ and T. The patterns of the corresponding bronchi of dog are so very different that no resemblance between the venous patterns is recognisable. In man the lateral segment is drained by the lateral vein (V₄ of Boyden and Hamre). The corresponding segment P₁ of dog is drained by the following veins (see Table 25):-

Vein P₁ - in 4 out of 18 lobes

Vein P₁-P₂ - " 9 " " " "

Lateral vein - " 17 " " " "

The medial segment in man is drained by the medial vein (V₅ of Boyden and Hamre). The corresponding area in the dog's lobe is drained by all the remaining veins, summarised in Table 25.

The existence of extensive variations of veins V₄ and V₅, detailed by Boyden and Hamre, and the lack of resemblance between the bronchial patterns, makes a comparison almost impossible. The comparison, therefore, is restricted to the lobar veins only. Boyden and Hamre's findings in man are compared to the findings in dog, in Table 55.

Thus in dog the lobar vein shows no variations in number and it opens directly into the left atrium with a greater frequency (61%) than does the corresponding middle lobe vein of the human lung (4%).

It is also concluded that a comparison of veins at segmental level is impracticable.

Table 55

VEINS OF THE RIGHT MIDDLE LOBE OF MAN
AND THE RIGHT CARDIAC LOBE OF DOG

(1) (Dog's terminology is given in parenthesis)	(2) MAN Boyden & Hamre (50 lungs)	(3) DOG (18 lungs)
	Ø	
I. No. of veins draining the lobe:		
1 vein	52% (64%)	100%*
2 veins	36% (36%)	0%
3 "	12% (0%)	0%
II. Drainage into upper lobar veins (veins of apical lobe)	14%	11% ≠
III. Drainage into inferior pulm- onary vein (caudal pulmonary vein, i.e., vein of the diaphragmatic lobe)	8%	0%
IV. Middle lobe vein (cardiac lobe vein) opens directly into left atrium	4%	61%

Ø Percentages in parenthesis are those given by Lindskog
et al (1949).

* This figure of 100% includes 11% specimens (≠ in column 3)
in which vein P₁ drained into the caudal vein of the apical
lobe (Specimens E50 and E56, page 196) and thus represented
a second vein of the lobe but it was of such an insignificant
size that it has been ignored.

COMPARISON BETWEEN THE VEINS OF RIGHT LOWER LOBE OF HUMAN,
AND RIGHT DIAPHRAGMATIC AND INTERMEDIATE LOBES OF DOG'S LUNG

Before a comparison can be made it is necessary to review the account of the veins of the right lower lobe of the human lung.

According to Ferry and Boyden, "the inferior pulmonary vein has two principal tributaries, a *superior vein* (V_6) draining the superior segment, and a *common basal vein* draining the basal segments. The latter is formed by the union of a *superior basal vein*, draining primarily segments B_8 and B_9 , and an *inferior basal vein* draining primarily segment B_{10} (or segments B_{9+10})" (Fig. 68C) This pattern they found in 78 per cent of the specimens. The remaining 22 per cent conform to their "anomalous patterns".

The veins, both in man and in dog, lie in the intersegmental planes. The plane which, in man, separates the medial basal segment from the rest of the right lower lobe is represented, in dog, by the sagittal fissure, which separates the intermediate lobe from the right diaphragmatic lobe. Due to this it is convenient to disregard these two areas, i.e., the medial basal segment and the intermediate lobe, at present, and deal only with the veins of the remaining areas first.

A comparison of the veins of the subsuperior zones (veins " V^* " and " VX^* ", of Ferry and Boyden, draining areas supplied by bronchi B^* and BX^*) with the corresponding veins in dog's diaphragmatic lobe, in view of their extreme variability, is omitted.

The planes separating the corresponding areas of the lower lobe of the human lung (excluding the mesial basal segment as

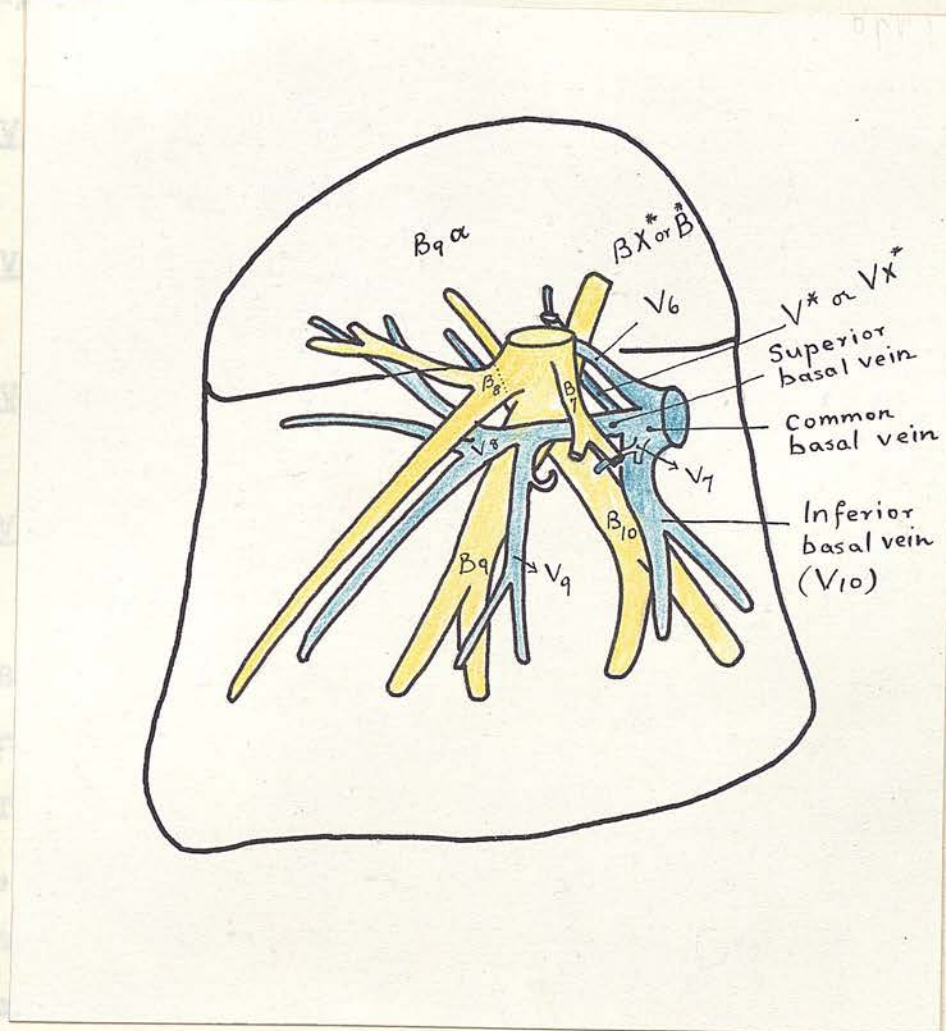


Fig. 68.C.— "Scheme showing common arrangement of veins in basal segments" of right lower lobe of human lung (After Ferry and Boyden, 1951 — Their Plate 1)

The lobe is "truncated" so that the apical bronchus is not shown.

stated above) and the diaphragmatic lobe of the dog's lung contain veins which obviously correspond. These veins are indicated below. A comparison of the intersegmental planes or spaces in which they lie may be made by comparing Figs. 68C and 42 .

<u>M a n</u>	<u>D o g</u>
<u>Vein V₆</u> - lying between bronchi B ₆ and B* (or BX*)	<u>Vein D₁-D₂</u> - lying between bronchi D ₁ and D ₂
<u>Vein V_{8b}</u> - lying between bronchi B ₈ and B ₉ .	<u>Vein V₁-V₂</u> - lying between bronchi V ₁ and V ₂
<u>Vein V₉</u> - lying between bronchi B ₉ and B ₁₀ .	<u>Vein V₂-T</u> - lying between (vein V ₂ -V ₃) bronchi V ₂ and V ₃
<u>Vein V₁₀</u> - drains segment B ₁₀ . (Posterior basal segment)	<u>Lobar Vein (beyond vein V₂-T)</u> - drains T-segment.

Before making any further comparison the following differences may be noted:-

The inferior pulmonary vein of the human lung, as stated above, is formed by the union of superior vein V₆ and the common basal vein. In dog the corresponding vein, i.e., the "caudal" pulmonary vein is formed by the union of the vein of the intermediate lobe and that of the diaphragmatic lobe, the union taking place outside the lobar hila. This difference is due to the fact that the vein, in the human lung, which corresponds to the vein of the intermediate lobe, i.e., the vein (or veins) of medial basal segment joins the lobar vein caudal to vein V₆. If, however, for the sake of facilitating comparison the commencement of the caudal pulmonary vein in dog be placed at the entry of vein D₁-D₂ (corresponding to

vein V_6 of man) in order to make the arrangement conform to that in human lung, then the lobar vein of the dog's diaphragmatic lobe distal to the point of entrance of vein D_1 - D_2 would correspond to the common basal vein of the human lung. But then, whereas in man the common basal vein drains four basal segments, the same in the dog would drain only three of the corresponding areas, viz., segments V_1 , V_2 , and area D_2 + T .

Looking for the "homologues" of the superior and inferior basal veins in dog, it can be seen in Fig. 68C that the superior basal vein is formed by the union of veins V_8 and V_9 , and the inferior basal vein is formed by vein V_{10} . In dog (Fig. 42) the "superior basal vein" is formed by vein V_1 - V_2 (with its tributary V_1) and the "inferior basal vein" by the lobar vein beyond the point of entry of vein V_1 - V_2 . However, either of these patterns are found both in man and in dog.

The frequency of the patterns of basal veins given by Ferry and Boyden (in their Table I) is compared with that of the corresponding patterns in dog in Table 56.

Thus, whereas pattern I(a) is more common in man (32% - Fig. 68C), pattern I(b) is the prevalent pattern in dog (66.67% - Fig. 42).

Veins of the Medial Basal Segment of Man and of the Intermediate Lobe of Dog

The veins of the medial basal segment, " V_7 ", according to Ferry and Boyden, range from one to six. They may open into superior basal, inferior basal or the inferior pulmonary vein. The intermediate lobe of dog was drained by one vein in 16 and 2 veins in 2 lobes but they all joined the vein of the diaphragmatic lobe.

Table 56*

COMPARISON OF THE VENOUS PATTERNS OF THE RIGHT
LOWER LOBE OF HUMAN, AND OF THE RIGHT
DIAPHRAGMATIC LOBE OF DOG'S LUNG

Formation of Superior Basal and of the Inferior Basal Veins	MAN Ferry & Boyden (50 lungs)	DOG (18 lungs)
(The corresponding veins of dog are given in parenthesis)		
I. Ferry & Boyden's "Uncomplicated" Types:-		
(a) Superior basal formed by V ₈ and V ₉ (veins V ₁ -V ₂ and V ₂ -T); inferior basal formed by V ₁₀ (lobar vein itself)	32%	5.55% (1 lobe)
(b) Superior basal formed by V ₈ (V ₁ -V ₂); inferior basal formed by V ₉ and V ₁₀ (V ₂ -T and the lobar vein)	6%	66.67% (12 lobes)
II. Ferry & Boyden's "Split" Types and all remaining types in dog; in these no correspondence is seen.	62%	27.78% (5 lobes)

* In this table the veins of dog, which correspond to the Superior and the Inferior Basal Veins of man, are also referred to as the "Superior" and the "Inferior" basal veins.

In 56% of the specimens, Ferry and Boyden have illustrated the inferior pulmonary vein passing dorsal to bronchus B₇. (Types I and II in their plate 4) In 24% they found the vein to pass between the two branches (B_{7a} and B_{7b}) - (Type III in their plate 4), and in 20% in which bronchus B₇ was absent, between the two branches "BX_{7a}" and "BX_{7b}" (representing bronchus B₇, and arising from neighbouring bronchi) - (Type IV in their plate 4). In dog the caudal pulmonary vein passed dorsal to the intermediate lobe bronchus in 100% specimens (18 lungs).

Vein "V₆" in Man and Vein D₁-D₂ in Dog

According to Ferry and Boyden, in 86% specimens, vein V₆ "swings round the medial side of lobar bronchus between superior and subsuperior bronchus". In 12% specimens it passed either between the branches of B₇ or beneath bronchus B*. In 4% ("2% included being included in the preceding category") segment B₆ was drained by 2 veins.

In dog the course of vein D₁-D₂, in 100% specimens (18 out of 18), was identical to the course of vein V₆ of man in 86% of Ferry and Boyden's specimens. In 2 specimens of dog (11.11%) there was an additional vein D₁ draining segment D₁, which has no homologue represented in Ferry and Boyden's patterns.

In 54% specimens Ferry and Boyden found an accessory vein "VX₆" draining segment B₆ into vein V₃ of the upper lobe. No identical drainage was found in dog.

Conclusions

- (1) Ignoring the veins of the medial basal segment and of the subsuperior zones of the right lower lobe of human lung, and the corresponding veins in the lung of dog, it may be concluded that the patterns are comparable but the modes of termination are different.
- (2) Veins of the medial basal segment and of the intermediate lobe are incomparable. Their sites of union with the lobar vein are different. In dog the vein of the intermediate lobe runs as an axial vein. No axial vein is recognisable in the medial basal segment of human lung. This difference may be associated with the absence of the sagittal fissure in human

lung and the different shapes of the medial basal segment and the intermediate lobe.

In man the left upper lobe, according to Boyden and Hartmann, is drained by veins V_1 , V_2 and V_3 of the upper division, and veins V_4 and V_5 of the lingula of the upper lobe. The only morphologically corresponding segments between these lobes were found to be the posterior segment or subsegment, B_3 , of the upper lobe of the human, and segment D_1 of the apical lobe of dog's lung (Table 32 item IX, 1(a) and (b)). That a comparison of venous drainage of segment B_3 with that of segment D_1 is difficult, is obvious from the following.

Segment B_3 is drained by vein V_3 which possesses three rami, " V_{3a} ", " V_{3b} " and " V_{3c} ". In 18 specimens examined the drainage of the corresponding segment D_1 of dog was:-

Veins P_1-D_1 and D_1-D_2	In 9 lobes
" P_1-D_1 , D_1-D_2 and D_1	" 4 "
" D_1-D_2 and D_1	" 2 "
" D_1-D_2 and D_1-V_1	" 1 "
" P_1-D_1 , D_1-D_2 and $D_1-D_2-D_3$ and D_1-D_2	" 1 "
" P_1-D_1 , D_1 and $D_1-D_2-D_3$	" 1 "
	18 lobes

Thus at segmental level the venous patterns do not resemble.

From the account given by Boyden and Hartmann, it has not been possible to find out the number of veins of the upper division of the upper lobe which drain independently into the superior pulmonary vein, but their figures for the lingular veins, which are available, are compared to those of the

in Table 57.

COMPARISON BETWEEN THE VEINS OF LEFT UPPER LOBE OF HUMAN, AND OF LEFT APICAL AND THE CARDIAC LOBES OF DOG'S LUNG

In man the left upper lobe, according to Boyden and Hartmann, is drained by veins V_1 , V_2 and V_3 of the upper division, and veins V_4 and V_5 of the lingula of the upper lobe. The only morphologically corresponding segments between these lobes were found to be the posterior segment or subsegment, B_3 , of the upper lobe of the human, and segment D_1 of the apical lobe of dog's lung (Table 32 item II, 1(a) and (b)). That a comparison of venous drainage of segment B_3 with that of segment D_1 is difficult, is obvious from the following.

Segment B_3 is drained by vein V_3 which possesses three rami, " V_3a ", " V_3b " and " V_3c ". In 18 specimens examined the drainage of the corresponding segment D_1 of dog was:-

Veins P_1-D_1 and D_1-D_2	in 9 lobes
" P_1-D_1 , D_1-D_2 and D_1	" 4 "
" D_1-D_2 and D_1	" 2 "
" D_1-D_2 and D_1-V_1	" 1 "
" P_1-D_1 , $D_1-d_2-D_3$ and D_1-d_2	" 1 "
" P_1-D_1 , D_1 and $D_1-d_2-D_3$	" 1 "
	—
	18 lobes
	—

Thus at segmental level the venous patterns do not resemble.

From the account given by Boyden and Hartmann, it has not been possible to find out the number of veins of the upper division of the upper lobe which drain independently into the superior pulmonary vein, but their figures for the lingular veins, which are available, are compared to those of the dog

Table 57

LINGULAR VEINS OF THE HUMAN, AND VEINS
OF THE LEFT CARDIAC LOBE OF DOG

(The terminology for dog is given in parenthesis)	MAN Boyden & Hartmann (50 lungs)	DOG (18 lungs)
Single lingular vein (vein of the left cardiac lobe)	52%	100%
Two separate veins, V ₄ and V ₅	48%	0%

Boyden and Hartmann found a vein from lingula (inferior lingular vein - V₅) to empty into the inferior pulmonary vein in 10% specimens. No example of a vein draining a part of the cardiac lobe draining into the corresponding caudal pulmonary vein was found in dog. However, there was one example in which the whole of the left cardiac lobe drained into the left caudal pulmonary vein (vein of the left diaphragmatic lobe) (See page 178; Plate VI Specimen M4).

In another 6% specimens they found that the inferior lingular vein received tributaries from the medial basal segment of the left lower lobe of the human lung. A "medial basal segment" in dog does not exist and, therefore, no corresponding example can be found.

The 10% and 6% specimens of Boyden and Hartmann, mentioned in the preceding two paragraphs, are examples of specimens in which the upper and lower lobes were incompletely separated, so that the veins mentioned above in these specimens were communicating veins. The only instances in dog of such communicating veins were two specimens in which vein D₁ of

the left diaphragmatic lobe drained into vein D_1-P_1 , but the major fissures in these lungs were complete. However, these veins in dog were small.

The above comparison of veins shows that, at segmental level, the venous patterns do not resemble, and that in dog the left cardiac lobe is constantly drained by a single vein, whereas in man it may be represented by one (52%) or two veins (48%). A comparison of the veins of the upper division of left upper lobe of human and the left apical lobe of dog's lung has not been possible.

Ewart has described four main veins in the left lower lobe of human lung. Their corresponding veins are indicated below:

Human	Dog
1. The posterior horizontal trunk	Superior basal (V_1)
2. Anterior basis	Anterior basal (V_2)
3. Axillary basis	Lateral basal (V_3)
4. Posterior basis	Posterior basal (V_4)
	Medial basal (V_5)

The planes, separating the corresponding areas of the human and dog's lungs indicated in Table 52 (Figs. 11, 12), would contain veins which would naturally correspond. These veins, using Boyden's terminology, are:

* Medial basal vein (V_5) appears that it corresponds to his "cardio-basis" vein, which is a "cardiac" vein, each of which is a "cardiac" vein.

COMPARISON BETWEEN THE VEINS OF LEFT LOWER
LOBE OF HUMAN, AND OF LEFT DIAPHRAGMATIC
LOBE OF DOG'S LUNG

No statistical study of the veins of the left lower lobe of human lung, taking into consideration the relationship of veins to bronchi, which form important landmarks for recognition of veins, has been found by the writer in literature. Ewart (1889) and Boyden (1945), however, have, without discussing variations, described them indicating their positions in relation to the bronchi. It is only, therefore, possible to indicate the corresponding vessels which drain identical areas.

Ewart has described four and Boyden five main veins in the left lower lobe of human lung. Their corresponding veins are indicated below:-

<u>Ewart</u>	<u>Boyden</u>
1. The posterior horizontal trunk	Superior vein (V ₆)
2. Anterior basic	Anterior basal (V ₈)
3. Axillary basic	Lateral basal (V ₉)
4. Posterior basic	Posterior basal (V ₁₀)
	Medial basal (V ₇)*

The planes, separating the corresponding areas of the human and dog's lungs, indicated in Table 32 (Item II, 3), would contain veins which would naturally correspond. These veins, using Boyden's terminology, are:-

* Medial basal vein (V₇) appears from Ewart's account to correspond to his "cardio-basic" vein or "anterior retro-cardiac" vein, each of which is a branch of his anterior basic vein.

Vein V₆ - lying between
bronchi B₆ and
the subsuperior
bronchi

Vein V₈ - lying between
bronchi B₈ and
B₉

Vein V₉ - lying between
bronchi B₉ and
B₁₀

Vein V₁₀ - drains segment B₁₀
(posterior basal
segment)

Vein V₇ - drains area B₇

Vein D₁-D₂ - lying between
bronchi D₁ and
D₂*

Vein V₁-V₂ - (with its tributary
V₁) - lying between
bronchi V₁ and V₂

Vein V₂-T - lying between
bronchi V₂ and V₃

Lobar Vein (beyond vein V₂-T)
- drains T-segment

No vein corresponding to vein
V₇ exists, because no bronchus
corresponding to B₇ exists in
dog.

SECTION IV

OTHER ANIMALS

DOMESTIC CAT

FALM CIVET

CHIMPANZEE

BHESUS MONKEY

GUINEA BABOON

Introduction

The bronchial trees of the remaining five animals, the cat, the civet, the chimpanzee, the rhesus monkey and the baboon, listed in Table I, and the pulmonary blood vessels of the cat, the civet and the baboon, will be dealt with briefly in the following pages.

Only a single specimen of the lungs of each of these five animals being included, it is not possible to describe their broncho-pulmonary segments. The use of the term, broncho-pulmonary segment, has, therefore, been avoided. The terms, "area" or "territory" have been used instead.

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Introduction

The bronchial trees of the remaining five animals, the cat, the civet, the chimpanzee, the rhesus monkey and the baboon, listed in Table 2, and the pulmonary blood vessels of the cat, the civet and the baboon, will be dealt with briefly in the following pages.

Only a single specimen of the lungs of each of these five animals being included, it is not possible to describe their broncho-pulmonary segments. The use of the term, broncho-pulmonary segment, has, therefore, been avoided. The terms, "area" or "territory" have been used instead.

The same system of nomenclature for bronchi and pulmonary vessels will be used as that used for dog.

Two rudimentary fissures were present in the right lung, one in the apical, and one in the diaphragmatic lobe.

The right apical lobe, as compared to that of dog, appears elongated in a cephalo-caudal direction and possesses a short caudal border so that it appears nearly triangular. It tapers into the apex of the lung which is more pointed than in dog.

The intermediate lobe is small. It differs from the dog's intermediate lobe in having its ventral end rounded so that it appears "shortened" and "contracted".

The remaining lobes showed no special characteristics.

The Bronchial Tree

The same terminology as used for the dog is applied to the cat.

Each lung possesses a stem-branch extending from the hilum to the

FELIS CATUS (DOMESTIC CAT)

A triple celloidin cast was prepared by injecting the bronchi and pulmonary vessels of a fresh pair of lungs obtained from an adult female domestic cat by writer's own method. (Figs. 3c and 3D)

External Morphology of Lungs
(Fig. 69)

The right lung consists of four and the left of three lobes identical to those of dog.

The two major, the right minor and the sagittal fissures were complete. The left minor fissure was three-fourths complete. At this fissure the apical lobe overlapped the cardiac lobe.

The cardiac notches were of about the same size on the two sides.

Two rudimentary fissures were present in the right lung, one in the apical, and one in the diaphragmatic lobe.

The right apical lobe, as compared to that of dog, appears elongated in a cephalico-caudal direction and possesses a short caudal border so that it appears nearly triangular. It tapers into the apex of the lung which is more pointed than in dog.

The intermediate lobe is small. It differs from the dog's intermediate lobe in having its ventral end rounded so that it appears "shortened" and "contracted".

The remaining lobes showed no special characteristics.

The Bronchial Tree

The same terminology as used for the dog is applicable to the cat.

Each lung possesses a stem bronchus of Leby which traverses the lung from the hilum to the most caudal end of the lung.

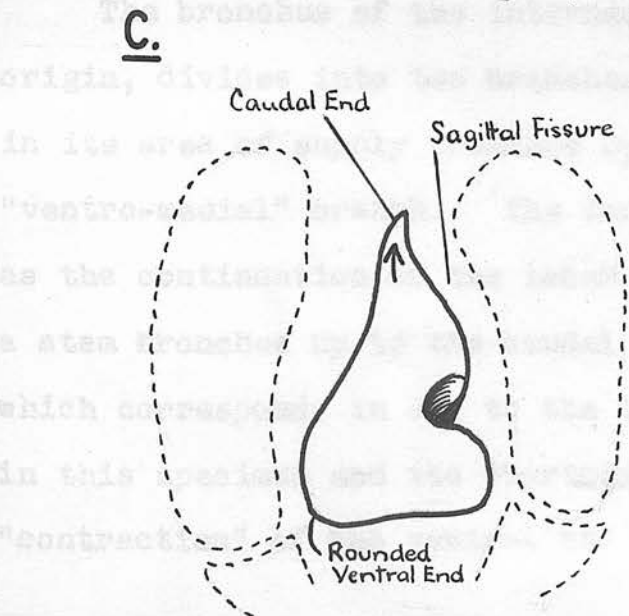
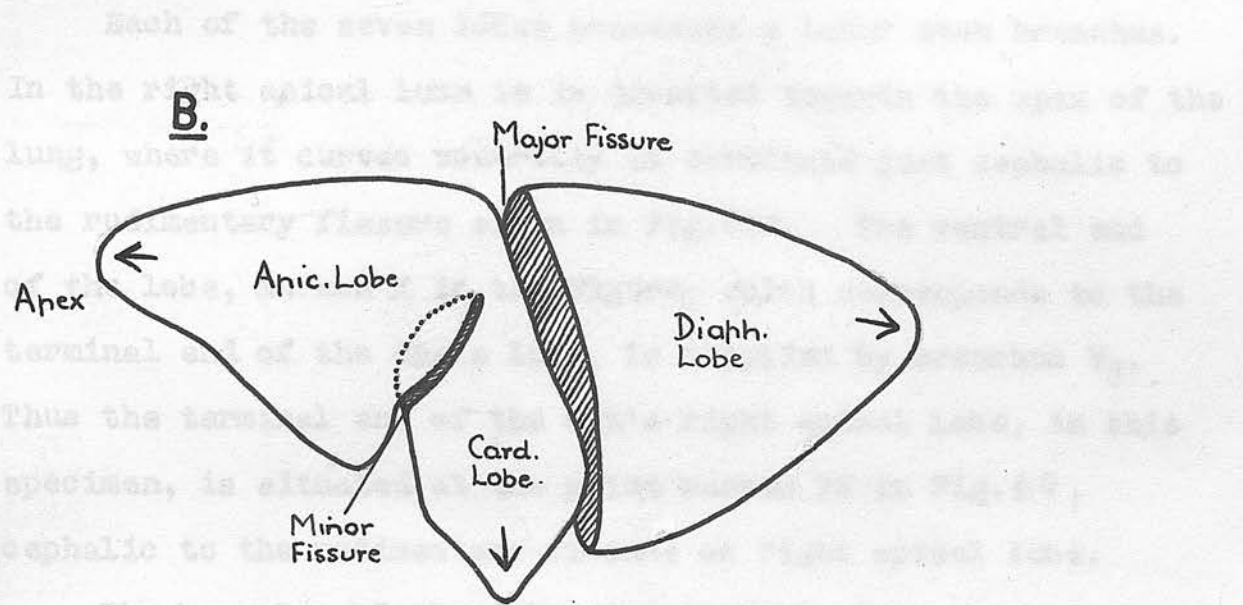
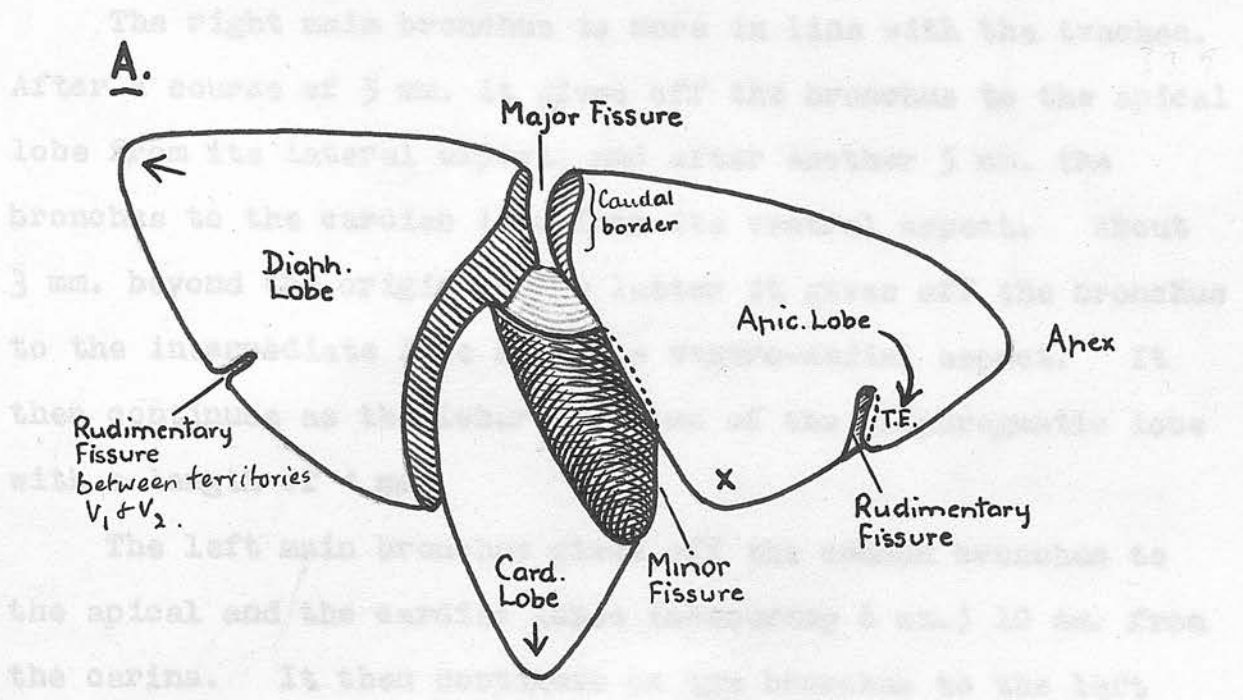


FIG. 69

THE LUNGS OF DOMESTIC

CAT.

- A. Right Lung
- B. Left Lung
- C. Intermediate Lobe-diaphragmatic view

Arrows point to the Terminal Ends.

The right main bronchus is more in line with the trachea. After a course of 5 mm. it gives off the bronchus to the apical lobe from its lateral aspect, and after another 5 mm. the bronchus to the cardiac lobe from its ventral aspect. About 3 mm. beyond the origin of the latter it gives off the bronchus to the intermediate lobe from its ventro-medial aspect. It then continues as the lobar bronchus of the diaphragmatic lobe with a length of 4 mm.

The left main bronchus gives off the common bronchus to the apical and the cardiac lobes (measuring 6 mm.) 10 mm. from the carina. It then continues as the bronchus to the left diaphragmatic lobe with a length of 7 mm.

Each of the seven lobes possesses a lobar stem bronchus. In the right apical lobe it is directed towards the apex of the lung, where it curves ventrally to terminate just cephalic to the rudimentary fissure shown in Fig. 69A. The ventral end of the lobe, marked X in the Figure, which corresponds to the terminal end of the dog's lobe, is supplied by bronchus V_3 . Thus the terminal end of the cat's right apical lobe, in this specimen, is situated at the point marked TE in Fig. 69, cephalic to the rudimentary fissure on right apical lobe.

The bronchus of the intermediate lobe, 6 mm. beyond its origin, divides into two branches, a dorsal, which resembles in its area of supply bronchus D_1 in dog, and a shorter "ventro-medial" branch. The former is bigger, and appears as the continuation of the lobar bronchus and is traceable as a stem bronchus up to the caudal end of the lobe; the latter, which corresponds in dog to the lobar stem bronchus, is short in this specimen and its shortness is associated with the "contraction" of the ventral end of the lobe referred to above.

CHART IX

BRONCHIAL TREE OF DOMESTIC CAT. - Branches of Lobar Stem Bronchi.

		Numerical Order of Branches.																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
RIGHT APICAL LOBE	}	P	V ₁	D ₁	l ₁	V ₂	D ₂	V ₃	D ₃	m ₁	V ₄	D ₄	v ₅	D ₅	v ₆	D ₆	D ₇	D ₈	v ₇ [?]	D ₉	m ₂	l ₂ [?]	21	
RIGHT CARDIAC LOBE	}	P ₁	A ₁	m ₁	P ₂	A ₂	P ₃	m ₂ /A ₃	P ₄	m ₃	P ₅	A ₄	+ 3 branches										15	
RIGHT DIAPHRAGMATIC LOBE	}	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	m ₂ /D ₄	m ₃	V ₃	m ₄	m ₅											12	
INTERMEDIATE LOBE	}	No serial arrangement recognisable.																					-	
LEFT APICAL LOBE	}	D ₁	V ₁	D ₂ /V ₂	D ₃	V ₃	D ₄	V ₄	D ₅	D ₆	V ₅	D ₇	v ₆	V ₇	D ₈									15
LEFT CARDIAC LOBE	}	P ₁	A ₁	A ₂	P ₂	A ₃	P ₃	A ₄	m ₁	P ₄	A ₅	m ₂	P ₅	A ₆	m ₃	P ₆	+ 3 branches.						18	
LEFT DIAPHRAGMATIC LOBE	}	D ₁	V ₁	D ₂	V ₂	D ₃	m ₁	V ₃	D ₄	m ₂	V ₄ /D ₅	D ₆ /V ₅	m ₃											14

← = Bifurcation of lobar stem bronchus.

A serial arrangement is not recognisable on it. Thus the terminal end of this lobe is its caudal end.

The lobar stem bronchi of the remaining five lobes terminate at the ends of their respective lobes which correspond to the terminal ends of the lobes in dog.

Except the intermediate lobe, as pointed out above, the remaining lobes possess series of branches comparable to those in dog. The branches in the order in which they appear are recorded in Chart IX.

The Pulmonary Arteries

The course and relations of the right and left pulmonary arteries are identical to those of dog's arteries.

Each of the seven lobes is served by one lobar artery, except the two apical lobes, each of which is supplied by two small additional arteries. The course of the main lobar artery in each of the lobes is also identical to the corresponding arteries in dog except in the intermediate lobe, in which the artery, after entering the lobar hilum, accompanies the lobar stem bronchus to the caudal end of the lobe unlike the artery in dog, in which both the lobar bronchus and the artery terminate at the ventral (terminal) end of the lobe. This difference is associated with the difference in the bronchial pattern described already.

The Right Apical Lobe

The right apical lobe receives three arteries arising independently from the pulmonary artery in the following order:

1. The cephalic artery
2. The caudal artery
3. An independent artery V₁.

The cephalic artery, the most cephalic structure in the right hilum, runs, as in dog, to attain the lateral aspect of the lobar stem bronchus by passing through interbronchial space D_1-D_2 . The only branch that originates from it, before it crosses over to the lateral side, is artery D_1 which is distributed with bronchus D_1 . All other branches arise as the artery runs along the lateral aspect of the lobar stem bronchus - one principal artery for each of the serial bronchi.

The caudal artery supplies the whole of the territory of P bronchus and has an origin and course as in dog.

Artery V_1 arises between the cephalic and the caudal arteries. It runs laterally, crossing ventral to the lobar stem bronchus, with the caudal vein intervening between the two, to meet and accompany bronchus V_1 .

The Right Cardiac Lobe

A single artery supplies the cardiac lobe, which originates about 4 mm. distal to the caudal artery of the right apical lobe, and accompanies the lobar bronchus giving off one principal artery to accompany each bronchus, as it runs along the lateral aspect of the lobar stem bronchus. The first artery to originate is P_1 , whose origin precedes the origin of the corresponding bronchus P_1 by about 2-3 mm.

The Intermediate Lobe

The artery to this lobe originates close to the origin of the artery to the cardiac lobe. Passing ventral to the stem bronchus, as in dog, it enters the lobar hilum to accompany the lobar stem bronchus up to the caudal end of the lobe. It gives off a large branch to accompany the ventro-medial bronchus.

The Left Apical Lobe

The main artery of the lobe, the first branch of the left pulmonary artery, originates as in dog, runs laterally, passes through interbronchial space D_1-D_2 , to gain the lateral aspect of the lobar stem bronchus. Thereafter, it accompanies it up to the terminal end of the lobe. It gives off branches along its course to each of the members of the two series of bronchi.

Bronchus D_1 , however, receives two independent arteries from the pulmonary artery, both of about equal size, one supplying the cephalic part, and the other, the caudal part of territory D_1 ; the latter part is supplied by the first lateral branch of bronchus D_1 . These two branches originate between the main (lobar) artery of the apical lobe and the artery of the cardiac lobe. In this respect the origins of the two arteries to area D_1 resemble the origin of artery D_1 in 3 of dogs' lungs, in which it has been described to have an independent origin from the pulmonary artery.

The Left Cardiac Lobe

This lobe is supplied by a single artery, whose course and distribution are identical to that in dog.

The Right and the Left Diaphragmatic Lobes

Each of these two lobes is supplied by the continuation of the respective pulmonary artery. The course and distribution of each of the two arteries are identical to that in dog.

One principal artery was seen to supply each of the bronchial territories in all lobes, but supplementary arteries, most of them minute in size, were found to supply some of the territories. The details of the number of arteries supplying

each of them are given in Table 58.

Table 58.

DETAILS OF THE NUMBER OF ARTERIES SUPPLYING
THE BRONCHIAL TERRITORIES* (One specimen)

Lobe	Territories supplied by two arteries	Territories supplied by three arteries
Right Apical	One principal and one small artery. D ₁ , D ₂ , V ₂	One principal and two small arteries. D ₃
Right Cardiac	One principal and one small artery. A ₁ , P ₂ , P ₃ , P ₄	-
Right Dia- phragmatic	Two arteries of equal size. D ₁ , D ₄	-
	One principal and one small artery. D ₂ , D ₃ , V ₁ , V ₂ ?V ₃	-
Left Apical	Two arteries of equal size (both independ- ent branches from pulmonary artery). D ₁	-
	One principal and one small artery. D ₂ , V ₂ , D ₃ , D ₄	-
Left Cardiac	One principal and one small artery P ₁ , P ₂	-
Left Dia- phragmatic	Two arteries of equal size. D ₁	-
	One principal and one small artery D ₂ , D ₃ , V ₁ , V ₃	One principal and two small arteries V ₂

* Observations have been restricted to those territories
which correspond to the bronchopulmonary segments of dog.

Since no serial arrangement of bronchi has been recognised in the intermediate lobe, this lobe has been omitted in Table 58. The territories which have been omitted in the Table were supplied by one artery each.

In some territories the additional arteries were injected so imperfectly that it has not been possible to state definitely whether an additional artery was present or not. These have been omitted.

The Pulmonary Veins

Main Pulmonary Veins

Three pulmonary veins open into the atrium.

The right apical and the right cardiac lobar veins join to form the right cephalic pulmonary vein which opens into the right cephalic part of atrium. Similarly on the left side the two lobar veins of the corresponding lobes form the left cephalic pulmonary vein, which opens into the left cephalic part of the atrium.

The lobar veins from the diaphragmatic lobes, one from each, join to form a short broad vein which opens into the caudal part of the atrium.

The single vein from the intermediate lobe opens into the right diaphragmatic lobe vein as in dog.

The Right Apical Lobe

The lobar vein commences near the terminal end of the lobe. It runs ventro-medial to the lobar stem bronchus and during its course receives tributaries from the inter-bronchial spaces of the two main series of bronchi.

In dog two main veins were described - a caudal and a cephalic. In this specimen, too, a caudal and a cephalic

vein are recognisable, but the former is relatively smaller than that of dog, and it appears more appropriate to consider it as a tributary of the cephalic instead of giving it the status of a main vein. Thus the caudal vein is the last tributary. Its course resembles that in the dog.

Other veins whose resemblance to the intersegmental veins of the dog can be recognised are:- veins V_1-V_2 , V_2-V_3 (V_2-T of dog), D_1-D_2 and D_2-D_3 (D_2-T) in dog. The largest tributary is vein V_2-V_3 .

The caudal vein receives the following tributaries identical to those of dog:-

1. Vein $P-D_1$
2. A lateral tributary
3. Vein $P-V_1$.

The medial tributary of the caudal vein is absent, but the dorso-caudal end of the P-territory is drained by a thin aberrant vein which runs medially and ventrally, crosses dorsal to the right stem bronchus to drain into the dorsal aspect of the common vein formed by the union of the vein of the diaphragmatic and of the intermediate lobes (Fig. 3C).

Thus the right apical lobe is drained by the main lobar vein and through this aberrant vessel into the vein of the right diaphragmatic lobe.

The Right Cardiac Lobe

The lobar vein commences near the terminal end of the lobe as in dog, and pursues a similar course, receiving on its way tributaries from interbronchial spaces.

The veins which correspond to those of dog are:-

veins P_1-P_2 , P_2-P_3 (corresponding to vein P_2-T of dog), A_1-A_2 and A_2-A_3 (corresponding to vein A_2-T of dog), A_1 and P_1 .

Vein P_1-P_2 is rudimentary, draining only the proximal part of the space P_1-P_2 . Its drainage is taken over by the next vein.

The lateral vein is large and compensates for the smallness of vein P_1-P_2 . Its course is identical to that in dog and receives a rudimentary vein from territory A_1 .

Vein A_1 drains the dorsal part of territory A_1 . It joins vein A_1-A_2 as its tributary, both forming a common stem before joining the lobar vein.

Vein P_1 is a large tributary draining the dorsal part of the territory P_1 . It joins the lateral vein just after the latter crosses lateral to the lobar artery.

Veins P_2-P_3 , A_1-A_2 and A_2-A_3 call for no special remarks.

The Right Diaphragmatic Lobe

The course of the ^{lobar} vein is identical to that in dog.

The following veins corresponding to the veins of dog can be identified:- veins D_1 , D_1-D_2 , D_2-D_3 (corresponding to vein D_2-T of dog), V_1 and V_1-V_2 .

Vein V_1 joins V_1-V_2 . All other veins open independently into the lobar vein.

The lobar vein receives the vein of the intermediate lobe as in dog and then the common stem thus formed receives the aberrant vein from the dorso-caudal part of the territory P of the right apical lobe as described already.

The Intermediate Lobe

A single vein drains the intermediate lobe. As the

pattern of bronchi does not exactly correspond to that in dog, veins identical to those described in dog are not recognisable. The main vein commences at the caudal end of the lobe and runs dorso-medial to the lobar stem bronchus receiving small multiple tributaries from the interbronchial spaces, one large vein from the area supplied by the ventro-medial branches, and another one from the cephalic part of the right (fissural) surface. It opens into the vein of the diaphragmatic lobe as in dog.

The Left Apical and Cardiac Lobes

In each lobe the course of the lobar vein is identical to that in dog. The following veins, which correspond to the veins of dog, are recognisable:-

(1) Vein D_1-P_1 (represented by two veins), which, as in dog, is common to both lobes, and drains territory D_1 of left apical lobe and P_1 of left cardiac lobe.

(2) Veins of the apical lobe - veins D_1-D_2 , D_2-D_3 (represented by 2 veins), D_3-D_4 (corresponding to vein D_3-T of dog), V_1-V_2 (represented by 2 veins) and V_2-V_3 (corresponding to vein V_2-T of dog).

(3) Veins of the Cardiac lobe - veins P_1-P_2 , P_2-P_3 , P_3-P_4 (corresponding to vein P_3-T of dog), and A_1-A_2 (corresponding to vein A_1-T of dog).

Their mode of termination was as follows:-

Space D_1-P_1 , as stated before, is drained by two veins. The proximal part is drained by a small vein which opens independently into the lobar vein of the cardiac lobe by crossing cephalic and lateral to the lobar bronchus. A separate vein from the distal part of the space passes

medially cephalic to bronchus D_1 of the apical lobe to pass through space D_1-D_2 , dorsal to the lobar artery of the apical lobe, and joins the common stem of veins D_1-D_2 and D_2-D_3 .

Vein D_2-D_3 passes medial to bronchus D_2 to enter space D_1-D_2 where it joins vein D_1-D_2 . The common stem so formed receives one of the two veins representing vein D_1-P_1 , as described above, and then joins the apical lobe vein after crossing medial to the lobar artery and bronchus.

Vein D_2-D_3 , mentioned above, drains the distal part of space D_2-D_3 ; the proximal part is drained by a rudimentary vein opening into the lobar vein independently. It is thus represented by two veins.

All the remaining veins open independently into their respective lobar veins as in dog.

The Left Diaphragmatic Lobe

The commencement and the course of the vein is identical to that on the right side.

The following veins corresponding to the veins of the dog were recognised:- veins D_1 , D_1-D_2 , D_2-D_3 and D_3-D_4 (corresponding to vein D_3-T of dog), V_1 , V_1-V_2 and V_2-V_3 (corresponding to vein V_2-T of dog).

Vein D_1 in dog, observed only in 2 lobes, was seen to drain into vein D_1-P_1 . In this specimen it drains the cephalic half of territory D_1 and, running medial to the root of bronchus D_1 and across the stem bronchus, drains independently into the lobar vein.

Vein V_1 drains into vein V_1-V_2 .

The remaining veins drain independently into the lobar vein.

NANDINIA BINOTATA (Two Spotted Palm Civet)

A triple celloidin cast was prepared by injecting the bronchi and pulmonary blood vessels of a fresh pair of lungs of adult female civet by writer's own method.

External Morphology of Lungs
(Fig. 70)

The lungs resemble, in their external morphology, those of the cat described already, except that the intermediate lobe, which was small, possessed a tapering ventral end. No rudimentary fissures were present. The left minor fissure was about half complete. The right cardiac notch was bigger than the left.

The Bronchial Tree	339

Each lung is traversed by a stem bronchus, traceable up to the most caudal end of the respective diaphragmatic lobe. The arrangement of the lobar bronchi is exactly identical to that in cat except that the terminal end of right apical lobe is situated at the apex of the lung, as on the left side.

Some of the measurements made were as follows:-

Right Side

From carina to right apical lobe bronchus	- 5 mm.
" apical lobe bronchus to cardiac lobe bronchus	- 7 mm.
" cardiac " " intermediate lobe bronchus	- 5 mm.
" intermediate lobe bronchus to bronchus D ₁ of diaphragmatic lobe	- 3 mm.

Left Side

From carina to common bronchus of apical lobe and cardiac lobe	- 9 mm.
" common bronchus of apical lobe and cardiac lobe to bronchus D ₁ of diaphragmatic lobe	- 6 mm.

Each lobe possesses a lobar stem bronchus with two main

series of bronchi as in dog. The terminal ends of the lobes are marked in Fig. 70 by arrows. In the intermediate lobe the terminal end corresponds to the dog's intermediate lobe, whereas in the dog's system it was seen to be at the caudal end of the lobe. The order in which the bronchi originate in each lobe is recorded in Chart X.

The course and relative positions of the right and the left pulmonary arteries are identical to those of the veins and the dogs' arteries.

Each of the seven lobes is served by one lobar artery and the right apical, the right apical, and the left apical lobes received two, one for the apical and one for the intermediate lobes respectively.

The right apical lobe is supplied by two arteries arising from the pulmonary artery:

1. The cephalic artery - for the supply of the cephalic lobe.
2. An artery which originates from the cephalic artery to supply territories of the apical and intermediate lobes. This is designated artery 7/2-3.
3. The caudal artery - for the supply of the caudal lobe.

The caudal artery is seen in its course and distribution.

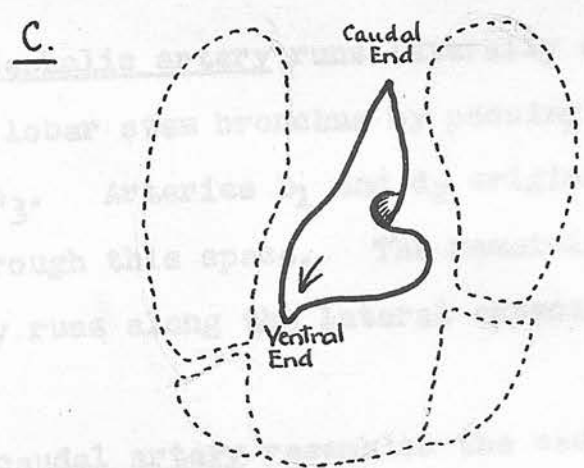
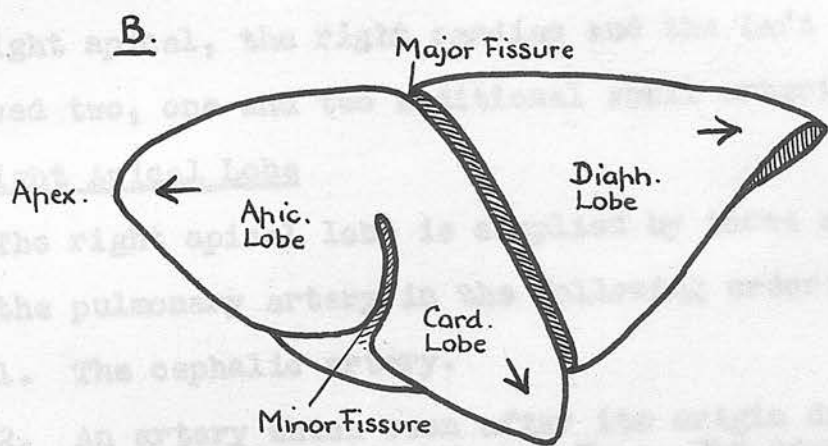
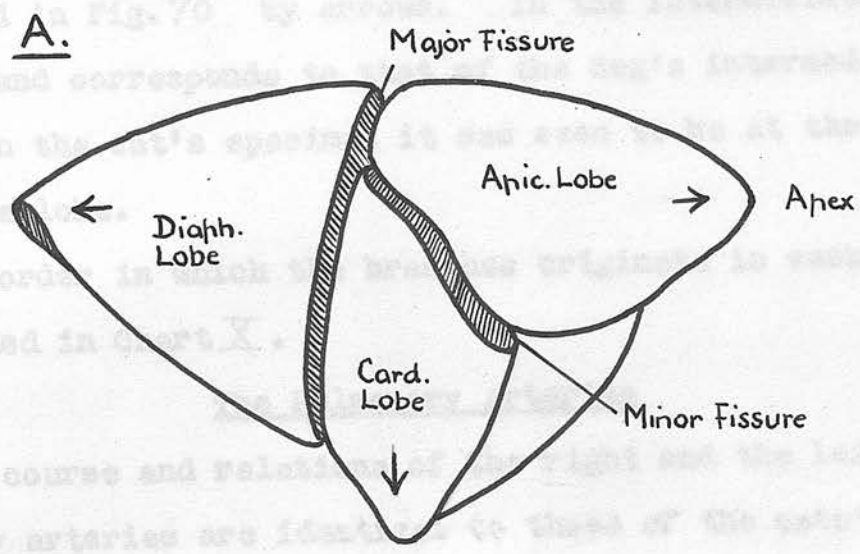


FIG. 70
THE LUNGS OF PALM CIVET

A. Right Lung
 B. Left Lung
 C. Intermediate lobe - diaphragmatic view

Arrows point to the Terminal Ends

series of bronchi as in dog. The terminal ends of the lobes are marked in Fig. 70 by arrows. In the intermediate lobe the terminal end corresponds to that of the dog's intermediate lobe, whereas in the cat's specimen it was seen to be at the caudal end of the lobe.

The order in which the branches originate in each lobe is recorded in Chart X.

The Pulmonary Arteries

The course and relations of the right and the left pulmonary arteries are identical to those of the cats' and the dogs' arteries.

Each of the seven lobes is served by one lobar artery but the right apical, the right cardiac and the left apical lobes received two, one and two additional small arteries respectively.

The Right Apical Lobe

The right apical lobe is supplied by three arteries arising from the pulmonary artery in the following order:-

1. The cephalic artery.
2. An artery which soon after its origin divides to supply territories V_1 and V_2 . The common stem is designated artery V_{1+2} .
3. The caudal artery - for the supply of the P-segment.

The cephalic artery runs laterally and cephalically to cross the lobar stem bronchus by passing through interbronchial space d_2 - D_3 . Arteries D_1 and d_2 originate from it before it passes through this space. The remaining branches arise as the artery runs along the lateral aspect of the lobar stem bronchus.

The caudal artery resembles the caudal artery of the cat in its course and distribution.

CHART X

BRONCHIAL TREE OF PALM CIVET. - Branches of Lobar Stem Bronchi.

Total number
of branches.

Numerical Order of Branches:-

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

RIGHT APICAL LOBE.	{	P D ₁ /V ₁ V ₂ d ₂ V ₃ D ₃ V ₄ D ₄ V ₅ D ₅ V ₆ D ₆ d ₇ v ₇ ? D ₈ V ₈ D ₉ m ₁ D ₁₀ ? <	20
RIGHT CARDIAC LOBE.	{	P ₁ A ₁ P ₂ m ₁ A ₂ m ₂ P ₃ m ₃ A ₃ P ₄ A ₄ m ₄	12
RIGHT DIAPHRAGMATIC LOBE.	{	D ₁ V ₁ D ₂ V ₂ m ₁ m ₂ D ₃ /V ₃ V ₄ /m ₃ D ₄ /V ₅ m ₄ m ₅ D ₅ ? m ₆	16
INTERMEDIATE LOBE.	{	D ₁ m ₁ D ₂ m ₂ D ₃ V ₁ D ₄ /m ₃ V ₂ D ₅ ? m ₄ V ₃	+ 2 branches. 14
LEFT APICAL LOBE.	{	D ₁ D ₂ V ₁ D ₃ V ₂ D ₄ V ₃ m ₁ D ₅ /v ₄ d ₆ V ₅ D ₇ m ₂	+ 2 branches. 16
LEFT CARDIAC LOBE.	{	P ₁ A ₁ m ₁ A ₂ P ₂ A ₃ P ₃ m ₂ α ₄ P ₄ m ₃ α ₅ P ₅ A ₆	+ 5 branches. 19
LEFT DIAPHRAGMATIC LOBE.	{	D ₁ V ₁ D ₂ V ₂ D ₃ /m ₁ V ₃ V ₄ D ₄ /m ₂ v ₅ m ₃ D ₅ V ₆ m ₄ v ₇ ? m ₅ V ₈ + 4 branches	22

< = Bifurcation of Lobar Stem Bronchus.
? = doubtful.

Artery V_{1+2} originates between the cephalic and the caudal arteries, close to the origin of the former, and immediately divides into two branches. One branch accompanies each of the two bronchi V_1 and V_2 , reaching the bronchi by crossing ventral to the lobar stem bronchus.

The Right Cardiac Lobe

Two arteries supply the right cardiac lobe. The principal lobar artery originates at the same level at which does the caudal artery of the apical lobe. It supplies the whole of the lobe except territory P_1 .

Territory P_1 is supplied by an independent small artery which originates from the pulmonary artery 3 mms. beyond the origin of the main lobar artery. It immediately meets bronchus P_1 to accompany it.

The main artery is distributed as in dog and in cat.

The Right Diaphragmatic Lobe

This lobe is supplied by the continuation of the pulmonary artery, its course being identical to the course of the corresponding artery in dog. It supplies one principal artery to accompany each of the bronchi.

The Intermediate Lobe

The artery to this lobe arises only about 2 mms. caudal to the independent artery, P_1 , of the cardiac lobe, and runs a course identical to that in dog to terminate, along with the lobar stem bronchus, at the ventral end of the lobe. During its course it gives off one branch to accompany each of the bronchi. Its course differs from the course of the corresponding artery in dog in its passing cephalic to the root of bronchus V_2 .

Left Apical Lobe

The left apical lobe is supplied by one principal lobar artery and two additional arteries which supply territory D_1 . The main lobar artery passes through interbronchial space D_1 - D_2 to gain the lateral aspect of lobar stem bronchus. It supplies the whole of the lobe except the area of bronchus D_1 .

The two additional arteries, arising independently from the pulmonary artery, were of about equal size. Each accompanies one of the two principal branches of bronchus D_1 . This arrangement resembles exactly the arrangement in cat already described.

Left Cardiac Lobe

The origin, course and distribution of the artery to this lobe is identical to that in dog and in cat.

Left Diaphragmatic Lobe

The course and distribution of the artery resembles that on the right side.

Each of the branches of the lobar stem bronchus is supplied by a principal artery.

The arteries of territories V_3 and V_4 possess a common stem which originates opposite interspace V_3 - V_4 , and then divides into two branches, one branch to accompany each of the two bronchi.

As in dog and in cat, one principal artery was seen to supply each of the bronchial territories in all lobes, but supplementary arteries, of minute size, were found for some of the territories. The details of the number of arteries supplying these territories are given in Table 59.

Table 59.

DETAILS OF THE NUMBER OF ARTERIES SUPPLYING
THE BRONCHIAL TERRITORIES *

Lobe	Territories supplied by two arteries	Territories supplied by three arteries
Right Apical	No additional arteries found.	
Right Cardiac	One principal and one small artery. A ₁ , P ₂ , P ₃	-
Right Dia- phragmatic	One principal and one small artery. D ₃ , V ₁ , V ₂ , V ₃ , V ₄	-
	Two arteries of equal size. D ₂	-
Inter- mediate	No additional arteries found.	
Left Apical	One principal and one small artery V ₁	-
Left Cardiac	One principal and one small artery. P ₁ , ? P ₂	-
Left Dia- phragmatic	One principal and one small artery D ₃ , D ₄ , V ₁ , V ₂ , V ₃	One principal and two small arteries D ₂

* Observations have been restricted to those territories which correspond to the bronchopulmonary segments of dog.

The territories omitted in the Table were supplied by a single artery each. Some additional arteries were so imperfectly injected and minute in size that it was not possible to state definitely whether an additional artery was present or not. These have been omitted.

The Pulmonary Veins

Main Pulmonary Veins

The arrangement of the main pulmonary veins is exactly identical to that of the veins of the cat, so that three veins, a right cephalic, a left cephalic, and a vein formed by the union of the two veins from the diaphragmatic lobes, open into the atrium.

The Right Apical Lobe

As in dog, two veins drain the right apical lobe, a cephalic vein and a caudal vein.

The cephalic vein commences at the terminal end of the lobe, i.e., at the apex of the lung, pursues a course as in cat, receiving veins from the interbronchial spaces of the lobe on its way. At the hilum it joins the caudal vein to form the lobar vein, which joins the vein of the cardiac lobe to form the cephalic pulmonary vein.

The caudal vein is formed by the tributaries which drain the territory of the P-bronchus and the adjoining parts of territories D_1 and V_1 , by tributaries draining interbronchial spaces $P-D_1$ and $P-V_1$; but distinct tributaries, identical to the four tributaries of the caudal vein recognised in dog, except vein $P-V_1$, were not identifiable. The medial vein is rudimentary, the lateral vein is "split" into two to three tributaries, and space $P-D_1$ is drained by three small veins. The main stem of the caudal vein, however, passes ventrally in the angle between bronchus P and the lobar stem bronchus, and joins the cephalic vein.

Other veins of this lobe corresponding to the veins of dog are:- veins D_1-d_2 , d_2-D_3 (corresponding to vein d_2-T of

dog - bronchus D_2 being rudimentary), V_1-V_2 and V_2-V_3 (corresponding to vein V_2-T of dog). They all open into the cephalic vein which is the main lobar vein.

The Right Cardiac Lobe

The lobar vein commences near the terminal end of the lobe and follows a course similar to that of the lobar vein of dog and of cat. The following tributaries identical to those of dog's lobe are recognisable:-

- (1) The "lateral" vein - It drains the adjacent parts of territories P_1 and P_2 , and, as in dog, crosses at first lateral to the lobar artery and bronchus, and then turning medially passes cephalic to them and dorsal to root of bronchus A_1 to enter the lobar vein. This vein entirely replaces vein P_1-P_2 , which is absent.
- (2) Vein P_2-P_3 (corresponding to vein P_2-T of dog) - It differs from the corresponding vein in dog in draining territories P_2 and P_3 from their lateral aspect, and in crossing lateral to the lobar artery and bronchus, (thus resembling the lateral vein). It joins vein A_1-A_2 to form a common stem which enters the lobar vein.
- (3) Vein A_1-A_2 - It joins vein P_2-P_3 , as mentioned above.
- (4) Vein A_2-A_3 - It joins vein P_3-P_4 , which has a course identical to vein P_2-P_3 , i.e., crosses lateral to the lobar artery and bronchus. The common stem formed, extremely short and about 1 mm. long, enters the lobar vein.

Three well marked tributaries from the ridge of the cardiac lobe, running under the cardiac surface, and draining the territories of m-branches, join the lobar vein independently.

The Right Diaphragmatic Lobe

(2) The lobar vein commences near the terminal end of the lobe, and runs a course identical to that of the corresponding vein of dog. It receives the following tributaries:- veins D_1-D_2 , D_2-D_3 and V_1-V_2 , draining areas indicated by their names.

Vein V_2-V_3 is absent. Space V_2-V_3 is drained by two tributaries, which cross medial to the stem of bronchus V_2 , to join vein V_1-V_2 . Strictly speaking, therefore, vein V_1-V_2 should be designated as vein $V_1-V_2-V_3$.

Vein V_1 , resembling vein V_1 of the corresponding lobe of dog, is absent as a large tributary, and is replaced by multiple small tributaries, all draining into vein V_1-V_2 .

The Intermediate Lobe

The lobar vein has a course identical to the course of the corresponding vein of dog.

Its tributaries are:- veins D_1-D_2 (corresponding to vein D_1-T of dog) and V_1-V_2 (corresponding to vein V_1-T of dog).

The lobar vein joins the vein of the diaphragmatic lobe to form the caudal pulmonary vein.

The Left Apical and the Left Cardiac Lobe

In each lobe the course of the lobar vein is identical to that in dog and in cat. The following veins, which correspond to the veins of dog, are recognisable:-

- (1) Vein D_1-P_1 , which, as in dog, is common to both lobes, and drains the adjoining parts of territory D_1 of left apical and P_1 of left cardiac lobe. It crosses lateral to the lobar artery and bronchus of the left cardiac lobe, and then, passing cephalic to them, joins the lobar vein of

the cardiac lobe.

(2) Veins of the left apical lobe.

The following veins are recognisable:-

(i) Vein D_1 - It drains the lateral aspect of territory D_1 , crosses lateral to the stem of bronchus D_1 and then passes dorsal to the lobar artery of the apical lobe through interbronchial space D_1 - D_2 to join vein D_1 - D_2 .

(ii) Vein D_1 - D_2 - It traverses the corresponding space, crosses medial to the lobar artery and bronchus, receives vein D_1 , as described above, and enters lobar vein.

(iii) Vein D_2 - D_3 - It is rudimentary.

(iv) Vein D_3 - D_4 (corresponding to vein D_3 -T of dog) - It drains primarily territories D_3 and D_4 but also receives small tributaries from the dorsal part of territory D_2 , thus compensating for the rudimentary vein D_2 - D_3 .

(v) & (vi) Veins V_1 - V_2 and V_2 - V_3 - They empty into the lobar vein as in dog.

(3) Veins of the left cardiac lobe. The veins present are:-

P_1 - P_2 , P_2 - P_3 , P_3 - P_4 (corresponding to vein P_3 -T of dog) and A_1 - A_2 (corresponding to vein A_1 -T of dog). They all open independently into the lobar vein.

The Left Diaphragmatic Lobe

The commencement and course of the lobar vein is identical to that of the right side. The tributaries are:- veins D_1 - D_2 , D_2 - D_3 , D_3 - D_4 (corresponding to vein D_3 -T of dog), V_1 - V_2 and V_2 - V_3 (corresponding to vein V_2 -T of dog). All drain independently into the lobar vein.

ANTHROPOPITHECUS TROGLODYTES

(Chimpanzee)

A bronchial cast was prepared by injecting celloidin, into a pair of lungs removed from an embalmed cadaver of an adult male chimpanzee, by writer's own method.

External Morphology of Lungs

(Figs. 71A, 71B, 71C, 71D)

The external form of the lungs was exactly identical to that of the human lungs.

The right oblique fissure was almost complete except for a small adherent area in the region of the dorsal border.

The left oblique and the right horizontal fissures were also complete, except for small areas of obliteration very near the hila.

The only rudimentary fissure present was a small cleft in the ventral border of the diaphragmatic surface of left lower lobe (Fig. 71D).

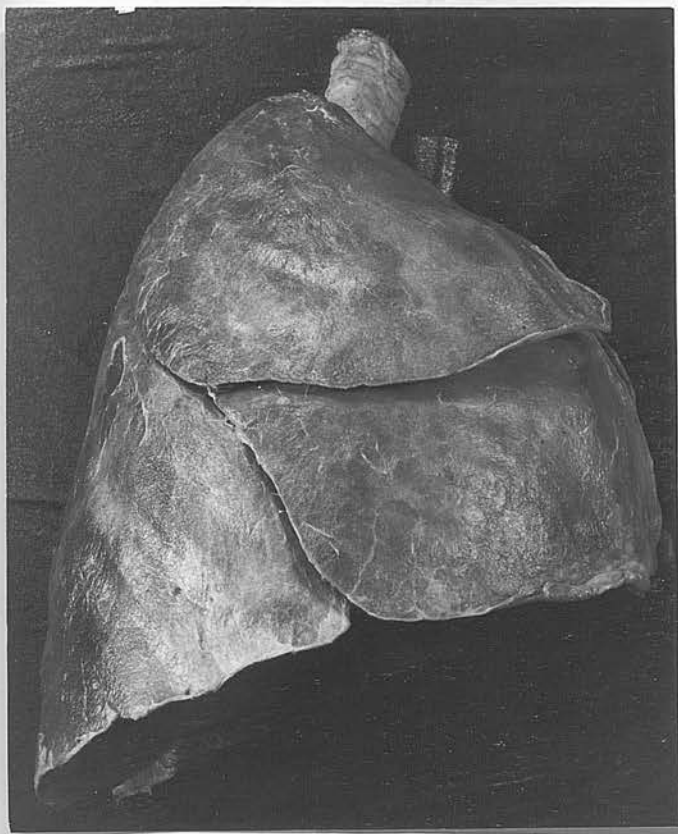
The Bronchial Tree

(Figs. 72a, 72b, 72c)

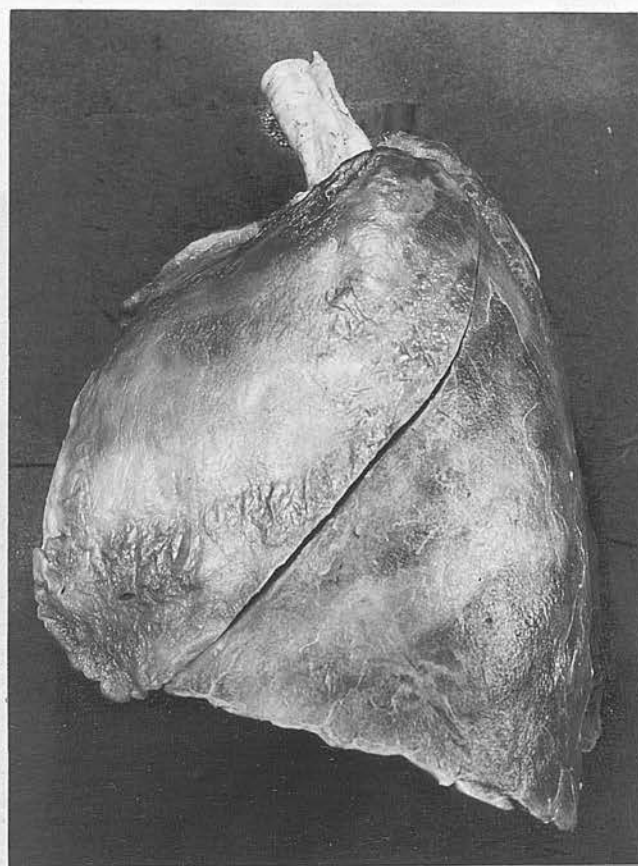
The bronchial pattern of the chimpanzee resembles the human bronchial pattern almost as closely as do the external appearances of their lungs. The human bronchial nomenclature, therefore, is exactly applicable to it and the same will be used.

The trachea bifurcates into the right and the left main bronchi, the former being more in line with the trachea than the latter.

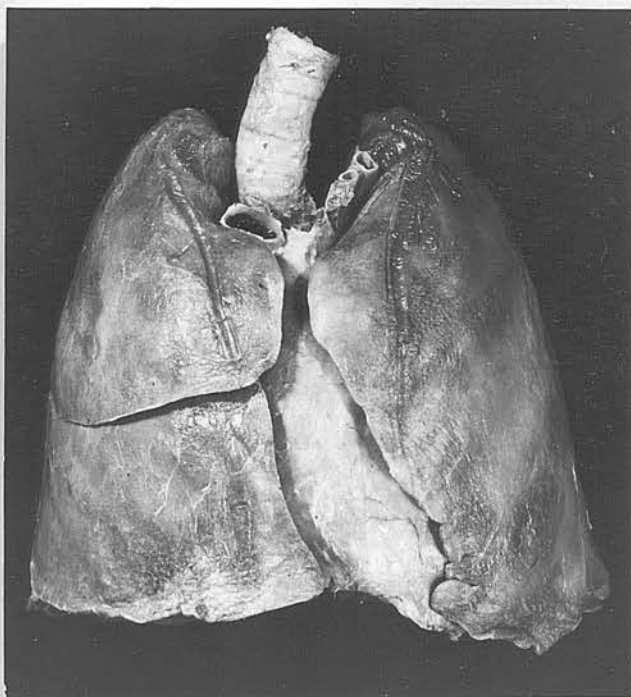
The right main bronchus gives off from its lateral aspect the upper lobe bronchus after a course of 2.5 cms. One cm.



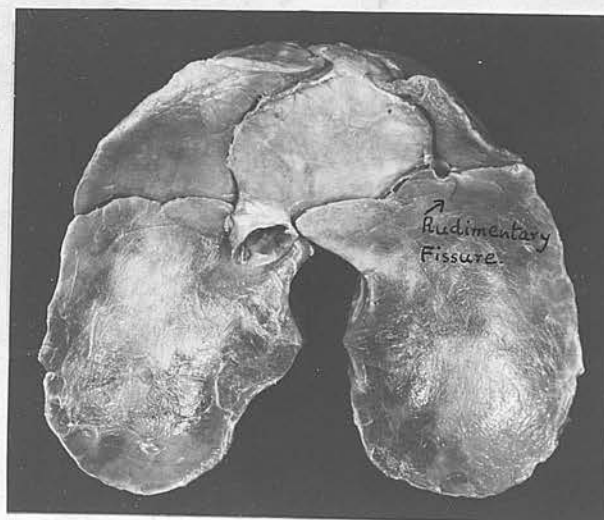
A. Right Lung - costal aspect



B. Left Lung - costal aspect



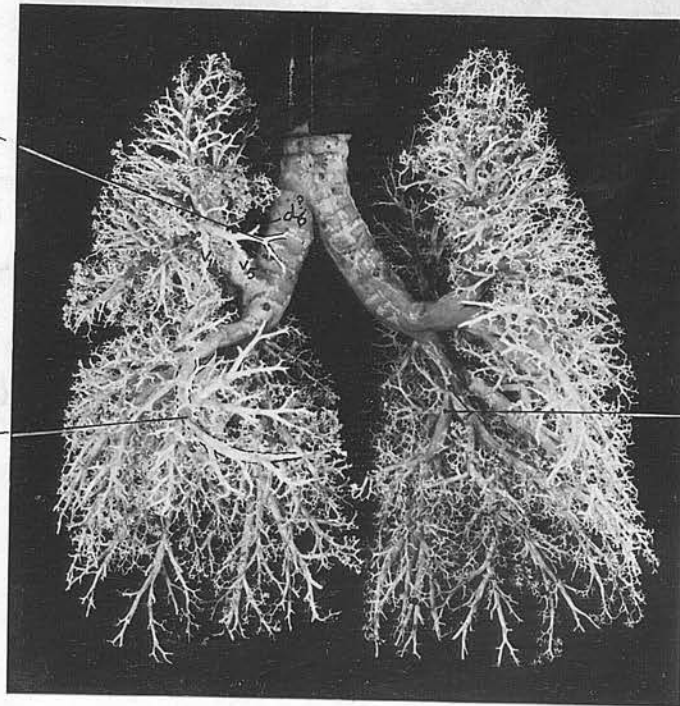
C. Ventral View of both Lungs



D. Diaphragmatic View of both lungs.

Point of
bifurcation
of anterior
segmental
bronchus.
(Lobar Stem
Bronchus).

Lobar
bronchus
running as
a stem
bronchus.
in Cardiac
lobe of
right lung



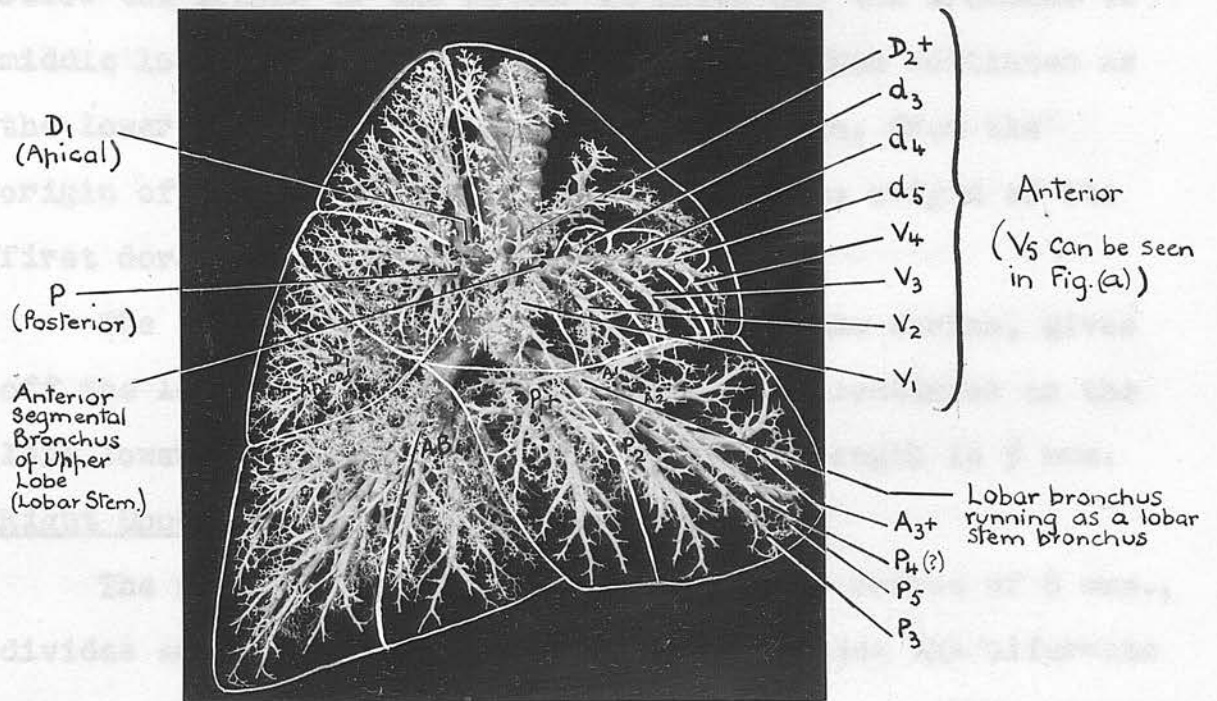
Branch corresponding
to the medial basal
bronchus of right side,
arising from Anterior
Basal Bronchus

(a.)

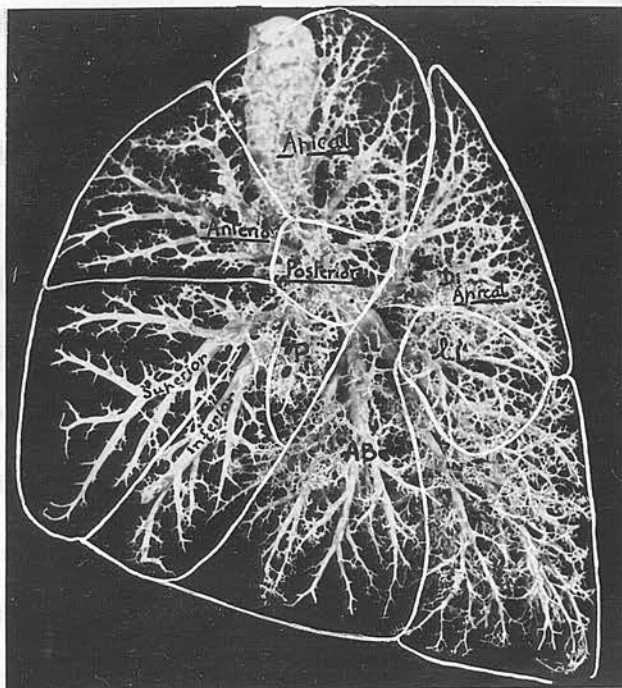
FIG. 72 Celloidin Cast of the Bronchial Tree of
Chimpanzee illustrated in Fig. 71

- a) Ventral View of both Lungs
- b) Right Lung - lateral view
- c) Left Lung - lateral view

AB = Ant. Basal



(b.)



(c)

below the origin of the latter it gives off the bronchus to middle lobe from the ventral aspect. It then continues as the lower lobe bronchus, the length of which, from the origin of the bronchus of middle lobe to the origin of its first dorsal branch, is 7 mms.

The left main bronchus, 4 cms. below the carina, gives off the left upper lobe bronchus, and then continues as the left lower lobe bronchus, whose undivided length is 5 mms.

Right Upper Lobe

The right upper lobe bronchus, after a course of 8 mms., divides according to a pattern which resembles the bifurcate type in the human lung, in which the apical and the posterior bronchi originate by a common stem. The lobar bronchus may, therefore, be described to divide into a "dorso-lateral" branch (the common stem of the apical and the posterior segmental bronchus, resembling the axillary apical trunk of Ewart - an arrangement found in writer's own Specimen 5 of the human bronchial cast), and an anterior branch, corresponding to the anterior segmental bronchus.

The apical bronchus supplies nearly the whole of the dorsal border of the lobe and the dorsal part of the apex - the ventral part being supplied by a branch of the anterior segmental bronchus (marked D_2^+ in Fig. 726).

The posterior bronchus divides and its ramifications spread almost parallel to the fissural surface bordering the oblique fissure, to supply the postero-inferior part of the lobe.

The anterior segmental bronchus runs horizontally forwards to supply the biggest area, the anterior segment.

As described in the human lung, this bronchus in the chimpanzee is also the continuation of the lobar bronchus. It not only supplies the largest area, but also it can be seen to run through the anterior segment, from its origin to the ventral end of the lobe, where it terminates by bifurcating (Fig 72a). A series of five bronchi of a descending order of size can be recognised to run parallel to the horizontal fissure. If these five bronchi be called the "ventral" bronchi as done in the right upper lobe of the human lung, then five branches are also recognisable as "dorsal" bronchi. But the first "dorsal" branch of the anterior bronchus is so much overdeveloped that the succeeding four rami are rudimentary branches, all of about the same size. They can clearly be seen to be in a row.

Thus the right upper lobe of the lung of this chimpanzee possesses a lobar stem bronchus, which, after giving off a common trunk for the apical and the posterior bronchi, continues as the anterior segmental bronchus giving off branches in two series, and terminates at the ventral end of the lobe by a terminal bifurcation. Denoting the bronchi, as done for the bronchi of the human upper lobes, the order of branches is represented in Chart XI.

Right Middle Lobe

The lobar bronchus runs in a ventral, lateral, and slightly caudal direction. After a course of 1 cm. it gives off a large branch from its postero-lateral aspect which supplies an area equivalent to about one-third of the whole lobe, similar to the lateral segment of the human lobe. The remaining two-third portion of the lobe, therefore, comprises the medial

segment. Thus the arrangement of the bronchi, if division of the lobe be restricted to these two areas or segments, resembles the usual pattern in the human lobe.

The medial bronchus, however, can be seen in Figs. 72a and 72b to be the direct continuation of the lobar bronchus, and on it can be recognised two main series exactly identical to the series recognised in dog. The bronchus itself terminates at the ventral end of the lobe as in dog.

Therefore, the right middle lobe of the chimpanzee possesses a lobar stem bronchus. The first branch described above, assumes the status of ramus P_1 (first caudal branch), which is so large that it supplies one-third of the lobe and resembles the lateral segmental bronchus.

Thus the middle lobe of the chimpanzee resembles the human lobe on the one hand and the dog's on the other.

The serial branches of the lobar stem bronchus, in the order in which they originate, are recorded in Chart XI.

Right Lower Lobe

The bronchus of the right lower lobe gives off from its dorsal aspect a branch which supplies an area exactly identical to the apical segment of the human lower lobe, and then continues as the basal trunk.

The next branch to arise, 2 mms. below the "apical", is the "medial basal" segmental bronchus.

Another 6 mms. lower down the basal trunk gives off the "anterior basal" bronchus and then rapidly bifurcates into the "lateral" and the "posterior basal" segmental bronchi, so that the main bronchus comes to an end. This is the type of division which is usually described as the "trifurcate" type.

and which is stated to be the prevailing mode of division in the left lower lobe of the human lung.

Left Upper Lobe

The bronchus of the left upper lobe, after a course of 10 mms., divides into an "upper" and a "lingular (lower)" division as in man.

The Upper Division Bronchus

This bronchus divides into three branches, in a manner which is usually described in man as the usual trifurcate pattern of the right upper lobe of human lung into an "apical", a "posterior" and an "anterior" segmental bronchus. Out of the three, the anterior bronchus is the thickest, supplies the biggest of the three areas, and is more in line with the upper division trunk than the other bronchi.

The anterior bronchus is directed in a ventral and in a slightly cephalic direction. Considering this as the continuation and the apical and the posterior bronchi as its side branches, two series of branches can be recognised; two branches, the apical and another, almost parallel and ventral to it, run parallel to the mediastinal pleura; and three branches, the posterior (directed laterally) and two other in the same plane are directed more ventrally and which overlap the lingular bronchi. If only the latter three branches were separated from the lingula by a "horizontal" fissure as on right side, the resemblance to the right upper lobe of man would be complete. Here one cannot help getting the impression that the lobar stem bronchus of the left apical lobe of dog, which is directed to the apex of the lung, has undergone, as it were, a "rotation" in an anti-clockwise direction when viewed from the costal

aspect to become the anterior segmental bronchus of the chimpanzee's lung. A similar appearance of a displacement or "rotation" of the lobar stem bronchus has been discussed in relation to the right upper lobe of human lung. This is not so clear in the photograph in Fig. 72c as on the actual specimen.

The branches which are directed cephalically would thus correspond to the "D"-series and the other three to the "V" series. The order of branches using letters D and V, despite their not representing the true directions of the bronchi, is represented in Chart XI.

The Lingular (Lower) Division

The lower division bronchus is directed ventrally and caudally. One cm. from its origin it gives off a lateral branch running along the oblique fissure. This branch resembles the first caudal branch, P₁, of left cardiac lobe of dog in its relation to the oblique fissure, in its being the first branch of the parent bronchus (corresponding to cardiac lobe bronchus) and in its direction. The lobar bronchus then undergoes a bifurcation into a "superior" and an "inferior" segmental bronchus, both of about equal size.

Left Lower Lobe

The lobar bronchus gives off, 6 mms. below the upper lobe bronchus, the first dorsal bronchus, which supplies the apical segment, and then continues as the basal trunk.

The next branch to arise, 6 mms. below the apical, is the "anterior basal" which supplies the corresponding segment.

The continuation of the basal trunk, after giving off a lateral branch, terminates by bifurcating into a "lateral

CHART XI

BRONCHIAL TREE OF CHIMPANZEE. - Branches of Lobar Stem Bronchi.

Total No. of Branches.

Numerical Order of Branches.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

RIGHT
UPPER
LOBE.

$P_1^1, V_1, D_2^1, V_2, d_3, m_1, V_3, d_4, m_2, l_1, d_5, V_4, m_3, l_2, V_5, d_6^? <$

RIGHT
MIDDLE
LOBE.

$P_1^1, m_1, P_2, A_1, A_2, P_3, l_1, A_3^1, P_4^?, m_2, P_5, l_2, m_3, P_6, l_3, P_7, m_4, l_4 + 2 \text{ branches.}$

RIGHT
LOWER
LOBE.

$D_1, MB, AB <$

LEFT UPPER
LOBE.

UPPER
DIVISION

$D_1, V_1, V_2, D_2, V_3, m_1 <$

LINGULA
(LOWER
DIVISION)

$P_1 <$

LEFT
LOWER
LOBE.

$D_1, AB, l_1 <$

$<$ = Bifurcation of Lobar Stem.

MB = medial basal.

AB = anterior basal.

? = doubtful.

basal" and a "posterior basal" segmental bronchus.

The anterior basal bronchus gives off from its medial aspect a branch which supplies an area corresponding to the medial basal segment of the right lung.

The order of branches is represented in Chart XI.

Summary

The bronchial pattern of the chimpanzee's lung is very similar to that of man, and the lungs are divisible into a pattern of segments which is identical to the universally recognised pattern of human lung.

The following points are worthy of notice as far as this cast is concerned:-

1. Right Upper Lobe

(a) The division of the lobar bronchus into segmental bronchi is identical to the usual mode of division of the upper division of the left upper lobe of human lung, i.e., the apical and posterior bronchi arise by a common stem - an arrangement described by Ewart as a normal arrangement.

(b) The anterior bronchus appears to be the continuation of the lobar stem as described in man.

2. Right Middle Lobe

The bronchial pattern resembles human as well as the dog's pattern.

3. Right Lower Lobe

The basal trunk appears to trifurcate - an arrangement described as the prevailing pattern in the left lower lobe of human lung.

4. Left Upper Lobe - Upper Division

The segmental bronchi arise by a trifurcate pattern - the prevailing mode of division in the right upper lobe.

The anterior segmental bronchus is the continuation of the upper division. In no human lung did it appear to be the continuation.

5. Left Upper Lobe - Lingular (Lower) Division

The bronchial pattern of the lingula, described above, is a pattern which is identical to the pattern described by Boyden and Hartmann (1946) found by them in 22% of 50 human lungs. (Their item 1, "Lower or lingular division" Table 1, page 326).

6. Left Lower Lobe

The origin of anterior basal bronchus in this cast is 13 mms. above the termination of basal trunk into the lateral and the posterior basal bronchi. In man, according to Brock, on the left side "the anterior basal arises a centrimetre or more above the origin of the other two bronchi" only "sometimes", the usual mode being an apparent trifurcation.

The presence of the lateral additional branch (ℓ_1 in Chart XI) corresponds to Neil and Co-worker's "subapical" bronchus which may originate, according to them, from any aspect of the lower lobe bronchus below the apical.

of "compression" was more marked in the apical lobes, so that the longitudinal axes of the lobes were in a dorso-ventral direction, whereas in dog their longitudinal axes were directed in a caudo-cephalic direction. The apices of lungs were rounded and not pointed like those of the lungs of dog.

The right apical lobe resembled the lower lobe of dog.

MACACA MULATA

(Rhesus Monkey)

A bronchial cast was prepared by injecting celloidin into a pair of lungs, removed from an embalmed cadaver, of an adult male rhesus monkey, by writer's own method.

External Morphology of Lungs

(Figs. 73A, 73B, 73C, 73D)

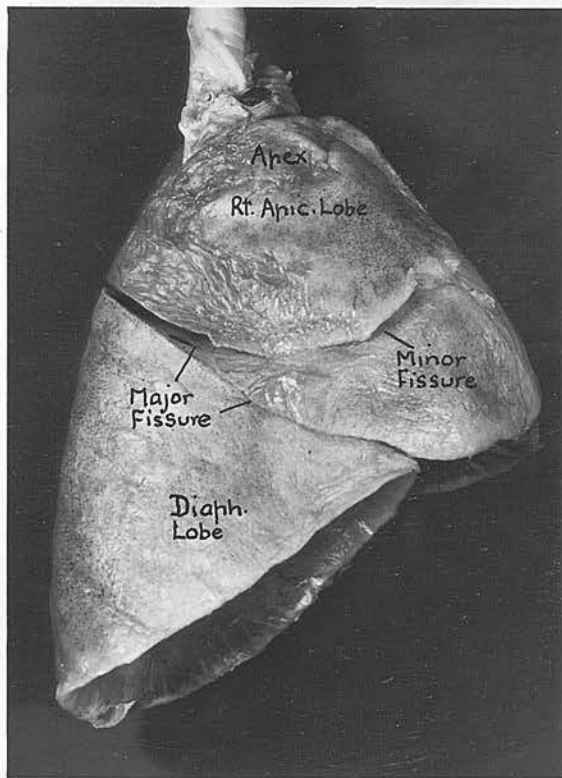
The right lung consists of four and the left of three lobes, identical to those of dog.

Both major fissures, the right minor and the sagittal fissures, were complete. The major fissures were placed slightly more obliquely than in dog. The left minor fissure was represented only by a superficial groove extending from the cardiac notch, for a short distance, in a dorsal and caudal direction. There were no rudimentary fissures in the lung.

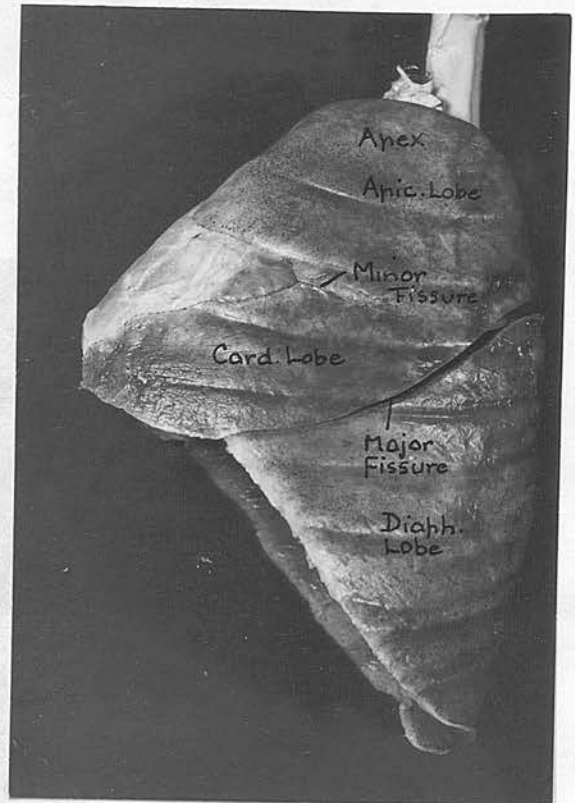
The general characters of the lungs differed from those of dog in the following respects:-

Both diaphragmatic lobes, as viewed from the costal aspect, appeared to be relatively more massive and the major fissures relatively more cephalically situated, than in dog. The apical and the cardiac lobes appeared as if they were "compressed" in a cephalico-caudal direction. The appearance of "compression" was more marked in the apical lobes, so that the longitudinal axes of the lobes were in a dorso-ventral direction, whereas in dog their longitudinal axes were directed in a caudo-cephalic direction. The apices of lungs were rounded and not pointed like those of the lungs of dog.

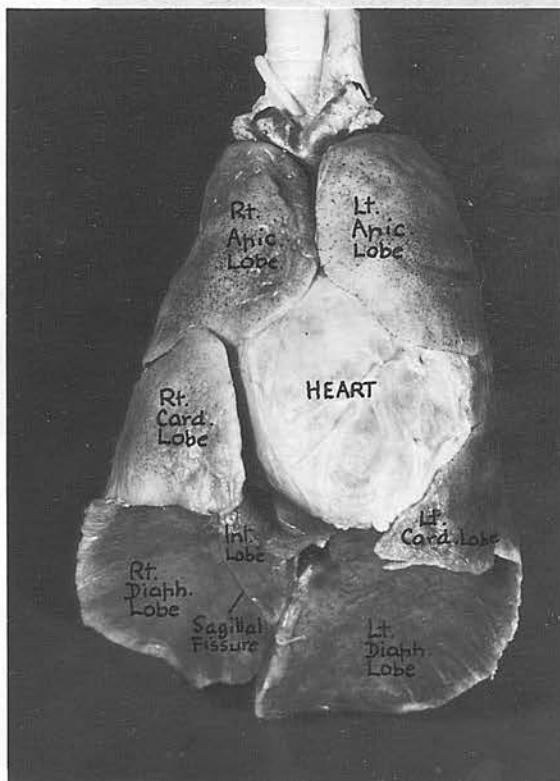
The right apical lobe resembled the human upper lobe.



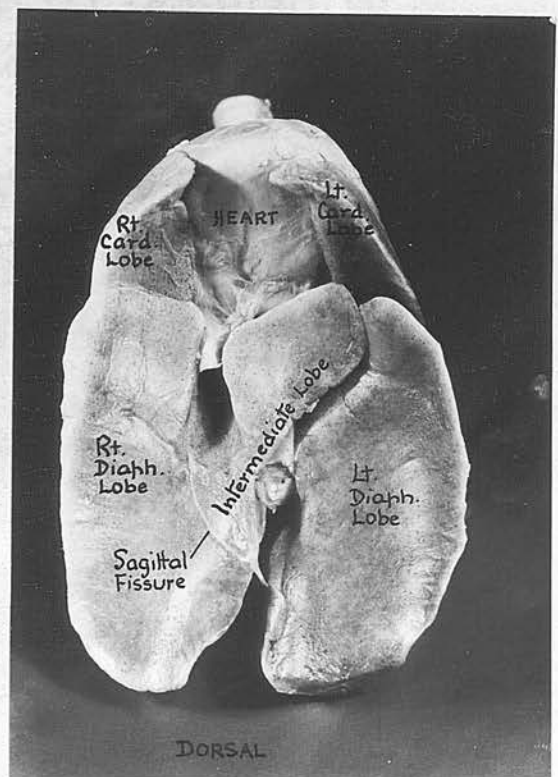
A. Right Lung - costal aspect



B. Left Lung - costal aspect



C. Both Lungs - ventral aspect



D. Both Lungs - diaphragmatic aspect

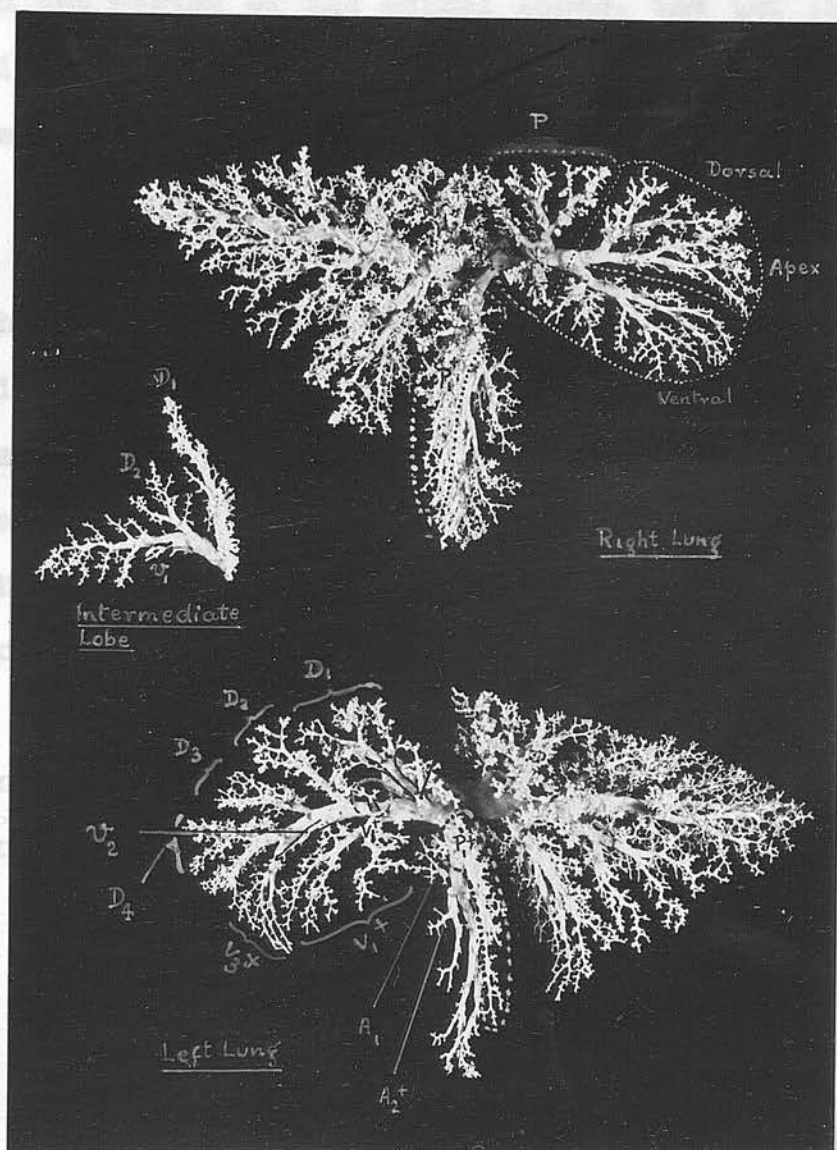


FIG. 74 Celloidin cast of the Bronchial Tree of Rhesus
Monkey prepared from Lungs illustrated in Fig. 73

Circle in left apical lobe marks l_1 . Bronchus P_1 in each cardiac lobe is encircled in dotted line. The three main divisions of right apical lobe are outlined. D_4 of left apical lobe supplies apex of left lung.

On the left side, the cardiac lobe was more slender in being longer and narrower than that of dog. This was associated with a large cardiac notch. The right cardiac notch was small.

In the region of the apical lobes, the two lungs together, when viewed from the ventral aspect, appeared broader from side to side than in dog. (Compare Figs. 50 and 73C).

The Bronchial Tree

(Fig. 74).

The trachea divides into the right and the left main bronchi which traverse the lungs as stem bronchi of Aeby to terminate at the most caudal ends of the respective diaphragmatic lobes.

The right main bronchus, more in line with the trachea, gives off, from its lateral aspect, the bronchus to right apical lobe, 8 mm. from the carina. It then gives off, from its ventral aspect, 8 mm. caudal to the preceding bronchus, the bronchus to the right cardiac lobe. The next bronchus to arise, 4 mm. beyond the cardiac lobe bronchus, is the bronchus to the intermediate lobe. It then continues as the bronchus to the diaphragmatic lobe, its undivided length being hardly 2 mm.

The left main bronchus gives off, 15 mm. from the carina, the common bronchus to the apical and the cardiac lobe, which, after a course of 10 mm., divides into two lobar bronchi, one for each lobe. It then continues as the bronchus to the diaphragmatic lobe, whose undivided length is 8 mm.

The Remaining Lobes

Each of the remaining lobes possesses a lobar stem bronchus. The general arrangement of bronchi resembles the arrangement

The Right Apical Lobe

The bronchial pattern is characterised by a very early bifurcation of the lobar stem bronchus. After giving off its first branch, identical to the P bronchus of dog, it terminates by bifurcating into two branches, which supply two equal sized areas. The lobe thus gets divided naturally into three segments, a P-segment, a "dorsal" segment and a "ventral" segment. The former bears on it the apex and may, therefore, be considered to correspond to the apical segment and the latter to the anterior segment of the human right upper lobe.

The Right Cardiac Lobe

The lobar bronchus traverses the lobe from its hilum to its ventral end, and on it two main series of bronchi are recognisable as in dog.

Bronchus P_1 originates from the caudo-lateral aspect of the lobar stem bronchus and is overdeveloped. The area it supplies extends along the caudal border of the lobe for more than half of its length. It tends to overlap the remaining lobe from the lateral aspect. If it was a little more overdeveloped and it overlapped the remaining lobe a little more, the resemblance between the bronchial arrangement of the human middle lobe and of this lobe would have been almost complete.

A noticeable feature is that the accessory bronchus m_1 is a well developed bronchus, which runs parallel to the lobar stem bronchus for a considerable distance under the medial border of the lobe.

The Remaining Lobes

Each of the remaining lobes possesses a lobar stem bronchus. The general arrangement of bronchi resembles the arrangement

in the corresponding lobes of dog. A few exceptional features are mentioned below.

The lobar bronchus of the intermediate lobe, near its origin, shows a deep curve, with the concavity directed dorso-medially, obviously meant for lodging the lobar vein of the diaphragmatic lobe.

In the left apical lobe, the lobar stem bronchus appears to undergo a bifurcation at the point of origin of bronchus V_3^+ . The dorsal of the two branches was considered to be the continuation, as it supplies a bigger area and deviates less from the lobar stem bronchus. The ventral branch has been considered and labelled as an overdeveloped third ventral bronchus (V_3^+) because it resembles the "V" series of branches in its origin and distribution.

In the left cardiac lobe, bronchus P_1 is so much elongated that it runs parallel to the lobar stem bronchus for nearly two-thirds of the whole length of the lobe, with the result that no other branches belonging to P series are recognisable.

In the two diaphragmatic lobes the bronchi were arranged as in the corresponding lobes of dog's lungs.

The branches of the lobar stems bronchi are recorded in Chart XII.

CHART XII

BRONCHIAL TREE OF RHESUS MONKEY. - Branches of Lobar Stem Bronchi.

		Numerical Order of Branches:-																				Total No of Branches.
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
RIGHT APICAL LOBE	}	P <																				1
RIGHT CARDIAC LOBE	}	P ₁ ⁺ m ₁ A ₁ ⁺ a ₂ h ₂ A ₃ ⁺ P ₃ m ₂ m ₃ a ₄ P ₄ m ₄ A ₅ m ₅ <																				14
RIGHT DIAPHRAGMATIC LOBE	}	D ₁ V ₁ D ₂ V ₂ m ₁ m ₂ D ₃ V ₃ /m ₃ /m ₄ m ₅ m ₆ D ₄ m ₇ V ₄ d ₅ m ₈ D ₆ m ₉ m ₁₀																				20
INTERMEDIATE LOBE.	}	D ₁ m ₁ D ₂ m ₂ v ₁ l ₁ V ₂ D ₃ m ₃ V ₃ D ₄ m ₄ d ₅ [?] /m ₅ V ₄ D ₆ m ₆ l ₂ [?] D ₇																				19
LEFT APICAL LOBE.	}	D ₁ V ₁ ⁺ l ₁ D ₂ v ₂ D ₃ m ₁ l ₂ V ₃ ⁺ l ₃ /m ₂ D ₄ l ₄ m ₃ m ₄ l ₅ <																				16
LEFT CARDIAC LOBE	}	m ₁ P ₁ ⁺ A ₁ A ₂ ⁺ m ₂ l ₁ <																				6
LEFT DIAPHRAGMATIC LOBE.	}	D ₁ V ₁ D ₂ V ₂ m ₁ D ₃ V ₃ m ₂ m ₃ v ₄ D ₄ m ₄ m ₅																				13

< = Bifurcation of Lobar Stem Bronchus

? = doubtful.

PAPIO PAPIO

(Guinea Baboon)

A triple celloidin cast was prepared by injecting the bronchi and pulmonary blood vessels of a fresh pair of lungs of an adult male baboon. (Figs. 76A and 76B)

External Morphology of Lungs

(Figs. 75A, 75B, 75C)

The right lung consists of four and the left of three lobes, as in dog.

Both major fissures and the right minor fissure were complete. The left minor fissure, as seen in Fig. 75A, was almost rudimentary (less than $\frac{1}{2}$ inch in depth). The sagittal fissure was nearly complete, except for a small band of lung tissue connecting the intermediate lobe with the right diaphragmatic lobe close to the hilum.

As in rhesus monkey, the diaphragmatic lobes, when viewed from the costal aspect, appeared to be more massive than those of dog, so that the major fissures appeared to have been "pushed" to a more cephalic position, resulting in the apical and the cardiac lobes getting "compressed".

Both apical lobes, the left cardiac lobe and the intermediate lobe, were relatively smaller than those of dog. The notch for the caudal vena cava, unlike the notch in dog, was situated on the ventral border of the intermediate lobe, and not on its right surface.

The apex of each lung was rounded, less so than in the monkey.

The configuration of the remaining lobes resembled that of the corresponding lobes of dog's lungs.

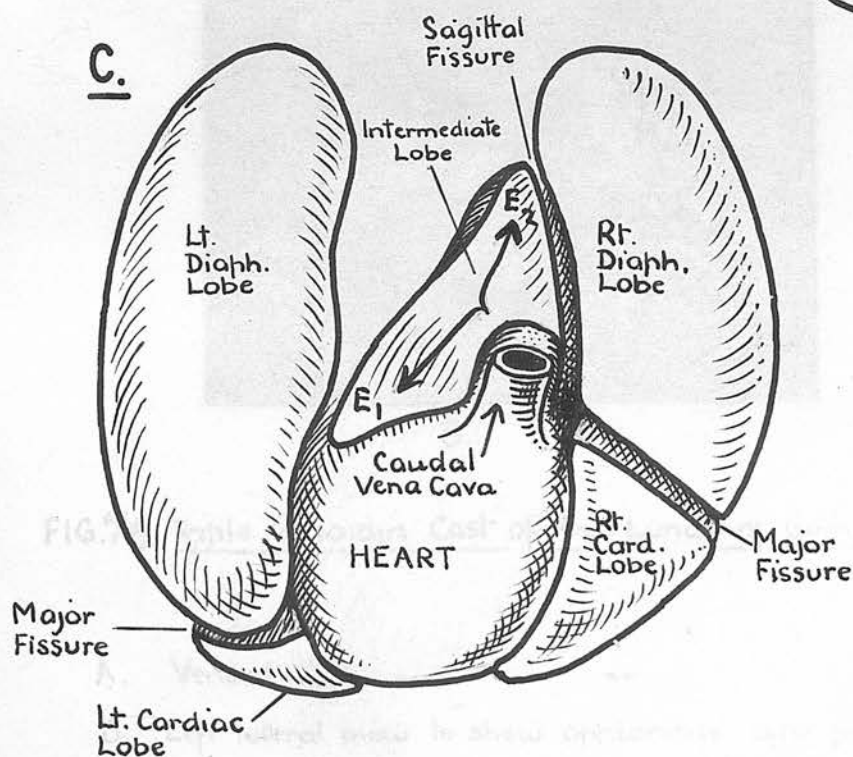
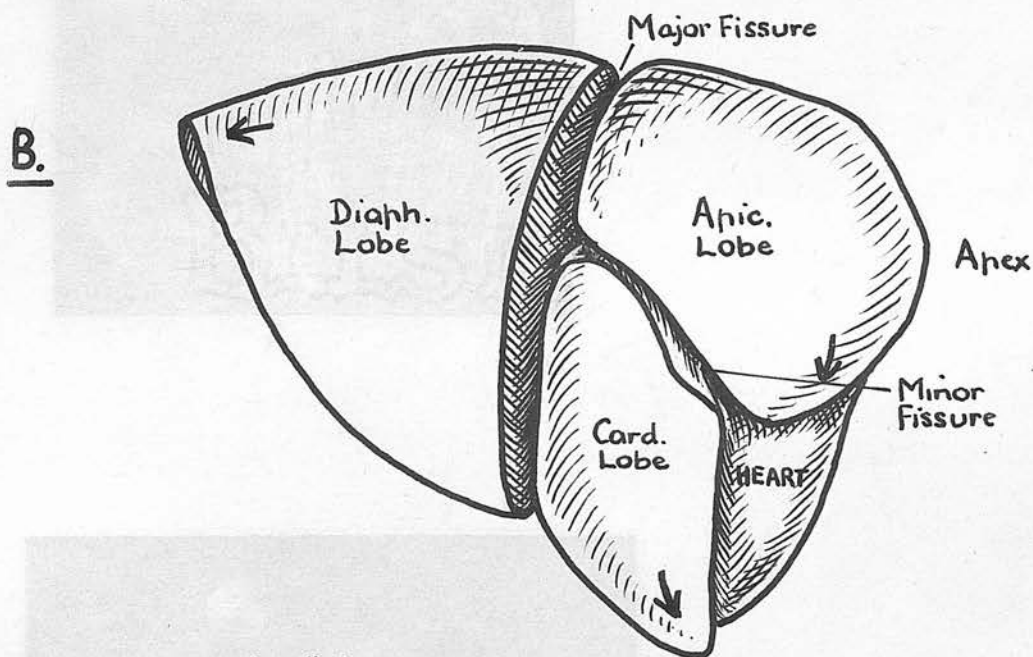
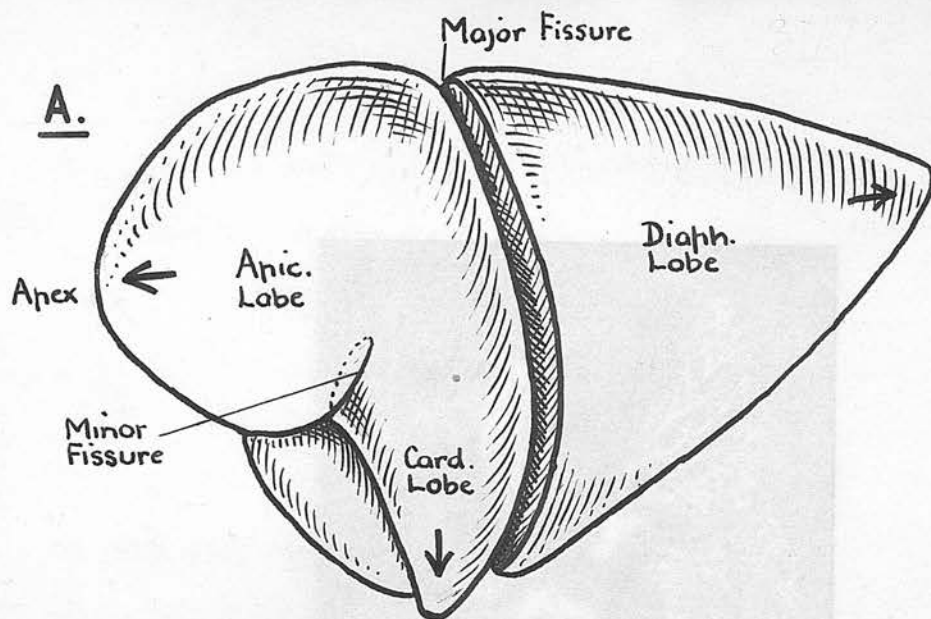


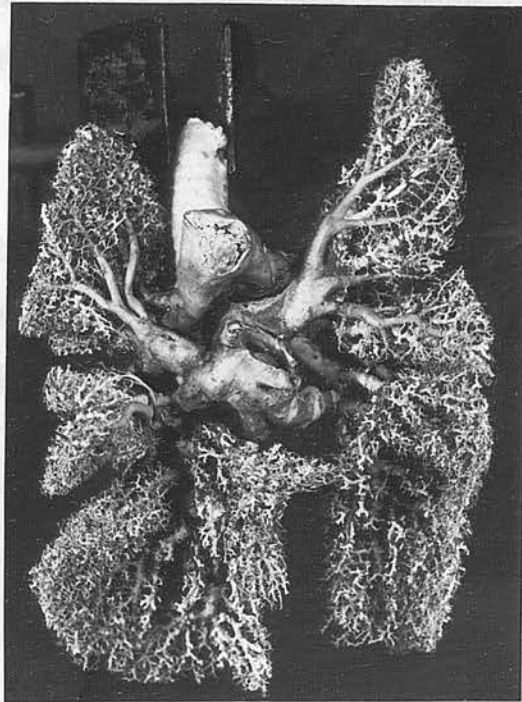
FIG. 75

THE LUNGS OF GUINEA

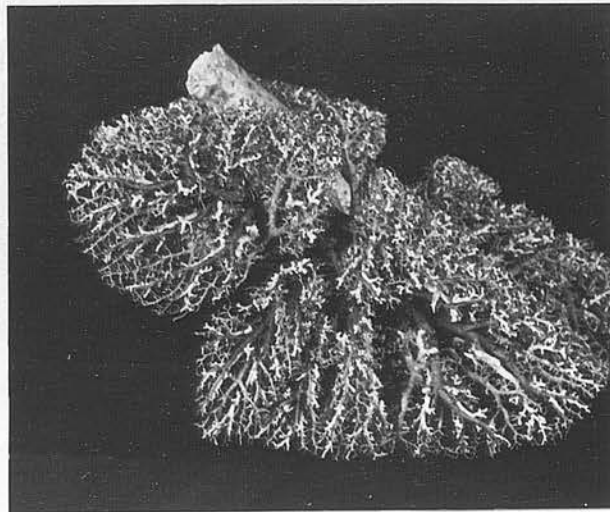
BABOON

- A. Left Lung
- B. Right Lung
- C. Diaphragmatic view of both lungs.

Arrows point to the Terminal Ends. The Terminal End of right apical lobe is not visible as it is curved round the cephalic aspect of the heart. Lobar bronchus of intermediate lobe bifurcates. Each of the two branches is directed towards ends marked E₁ and E₂.



A.



B.

FIG.76 Triple Celloidin Cast of the Lungs of Guinea Baboon

A. Ventral view

B. Left lateral view to show appearance after pruning.

The cardiac notches were of about equal size on both sides.

The broadening of the lungs, in the region of the apical lobes, was not so well marked as in the monkey.

The Bronchial Tree

Each lung is traversed by a stem bronchus traceable up to the most caudal end of the respective diaphragmatic lobe.

The right main bronchus is more in line with the trachea. It gives off, from its lateral aspect, the bronchus to right apical lobe, after a short course of 5 mm. After a further course of 11 mm. it gives off from its ventro-lateral aspect, the bronchus to cardiac lobe. The next branch to arise, 2 mm. beyond the preceding branch, is bronchus D_1 of the diaphragmatic lobe, 5 mm. beyond which the bronchus to the intermediate lobe originates from the ventro-medial aspect. The stem bronchus then continues to supply the rest of the diaphragmatic lobe.

The left main bronchus runs caudally and laterally for about 16 mm. before it gives off, from its ventro-lateral aspect, the common bronchus for the apical and the cardiac lobes. It then continues to supply the diaphragmatic lobe, its undivided length being 7 mm.

The Right Apical Lobe

The lobar bronchus proceeds laterally. About 8 mm. from its origin it gives off its first branch which supplies an area identical to the P-segment of dog's lobe. It then curves cephalically and ventrally. At the convexity of the curve, from its ventro-lateral and caudal aspect, it gives off the first and the only ventral branch (V_1) which is so

much overdeveloped that no other ventral bronchus is present. The lobar stem bronchus then gives off its first dorsal branch which is underdeveloped (d_1). At the origin of the next branch (D_2), the lobar stem undergoes a sharp change of direction and after giving off two branches, one from the ventro-lateral aspect (ℓ_1) and the other from the medial aspect (m_1), it terminates $\frac{3}{4}$ inch from the terminal end of the lobe by undergoing a bifurcation.

The serial arrangement, on account of an early bifurcation of the stem and a fewer number of branches, is not well marked.

The Right Cardiac Lobe

The right cardiac lobe bronchus traverses the lobe, as a stem bronchus, from the hilum to the ventral end of the lobe. Two main series of branches are recognisable, but are not so clearly marked as in dog.

Bronchus P_1 is so much overdeveloped that, at first sight, the lobar bronchus appears to divide into two main branches, a lateral and a medial, the former being P_1 and the latter, the continuation of the lobar bronchus. The area supplied by bronchus P_1 tends to overlap the rest of the lobe from the lateral aspect, so that the arrangement here resembles the normal arrangement in the human lung. But the medial branch supplies an area about twice the size of the area supplied by the lateral branch, and has on it branches which can be recognised to be in series. The medial branch, therefore, has been considered as the continuation of the lobar bronchus.

In each of the two lobes the bronchus runs as

The Right Diaphragmatic and the Intermediate Lobe

The first branch of the stem bronchus, 2 mm. beyond the origin of the cardiac lobe bronchus, is the first dorsal branch, D_1 , of the diaphragmatic lobe. The next branch, the bronchus to intermediate lobe, arises 4 mm. from bronchus D_1 , from the ventro-medial aspect of the stem bronchus. It then continues to supply the rest of the diaphragmatic lobe. On it two main series of branches are recognisable.

A single bronchus for the diaphragmatic lobe, thus, cannot be said to exist, as it is supplied by: (1) bronchus D_1 , a branch of the stem bronchus preceding the origin of the intermediate lobe bronchus, and (2) the continuation of the stem bronchus, beyond the origin of the intermediate lobe bronchus.

In Chart XIII, the sign \uparrow is meant to indicate the site of origin of the intermediate lobe bronchus, between bronchi D_1 and D_2 .

The intermediate lobe is small. Its bronchus, 9 mm. from its origin, divides into two branches - a dorsal branch, which, in distribution, resembles bronchus D_1 of dog, and a ventro-medial branch which resembles the continuation of the lobar bronchus of dog in supplying an identical area. The areas supplied by these two branches are of equal size.

The serial arrangement is not well marked.

The Left Apical and The Left Cardiac Lobe

The common bronchus of these two lobes, after a short course of 7 mm., divides into the bronchus for apical and the bronchus for cardiac lobe.

In each of the two lobes the bronchus runs as a stem

CHART XIII

BRONCHIAL TREE OF GUINEA BABOON - Branches of Lobar stem Bronchi.

Total No.
of Branches.

		Numerical Order of Branches. 1 2 3 4 5 6 7 8 9 10 11 12 13 14	
RIGHT APICAL LOBE	}	P V ⁺ d ₁ D ₂ l ₁ m ₁ ←	6
RIGHT CARDIAC LOBE.	}	P ₁ ⁺ A ₁ m ₁ 1/2 P ₃ ⁺ a ₂ A ₃ ⁺ 1/2 m ₂ l ₁ [?] ←	10
RIGHT DIAPHRAGMATIC LOBE.	}	D ₁ D ₂ V ₁ D ₃ V ₂ /m ₁ m ₂ /D ₄ m ₃ V ₃ m ₄ D ₅ [?] m ₅ ← ↑	13
LEFT APICAL LOBE	}	D ₁ V ₁ D ₂ V ₂ m ₁ D ₃ ⁺ V ₃ ⁺ m ₂ d ₄ V ₄ d ₅ m ₃ + 6 branches ←	18
LEFT CARDIAC LOBE	}	m ₁ A ₁ P ₁ ⁺ a ₂ m ₂ A ₃ ⁺ P ₂ P ₃ m ₃ l ₁ P ₄ /m ₄ + 3 branches.	15
LEFT DIAPHRAGMATIC LOBE.	}	D ₁ V ₁ V ₂ D ₂ V ₃ /m ₁ D ₃ m ₂ V ₄ m ₃ m ₄ V ₅ ⁺ D ₄ m ₅ ←	14
INTERMEDIATE LOBE	}	Serial arrangement not marked.	

← = Bifurcation of Lobar stem bronchus.

? = doubtful.

bronchus, from the hilum to the respective terminal ends, giving off two main series of bronchi as in dog.

The Left Diaphragmatic Lobe

Two main series of branches are recognisable as in the right diaphragmatic lobe.

An interesting observation is the presence of a side branch of bronchus V_1 which reminds one of bronchus " B_7 ", described by Berg, Boyden and Smith (1949), as a side branch of their bronchus " B_8 ".

This side branch of bronchus V_1 supplies a small medial part of the territory V_1 , which, as seen in dog, corresponds morphologically to the anterior basal segment supplied by the anterior basal bronchus, B_8 . Berg, Boyden and Smith found B_7 to be present in 87% of their specimens as a side branch of B_8 .

The order of appearance of the branches of lobar bronchi is recorded in Chart XIII.

The Pulmonary Arteries

The course and relations of the right and the left pulmonary arteries are identical to those of the dog's pulmonary arteries.

Each of the right apical, the right cardiac and the left apical lobes are supplied by two arteries. The right diaphragmatic lobe is supplied by the continuation of the right pulmonary artery, and by one of its branches, artery D_1 , the origin of which precedes the origin of the artery to intermediate lobe. Each of the remaining three lobes is supplied by a single artery, the left diaphragmatic lobe being supplied by the continuation of the left pulmonary

artery.

The Right Apical Lobe

The right apical lobe is supplied by two arteries, a cephalic and a caudal, the former supplying the major part of the lobe, as in dog.

The Cephalic Artery - It differs from the cephalic artery described in other animals in remaining along the medial aspect of the lobar stem bronchus. Its branches too are distributed along the medial aspects of their companion bronchi, but the terminal ramifications tend to run along the lateral aspects.

The cephalic artery is the first branch of the right pulmonary artery. After a short course of about 6 mm., it gives off a large branch to accompany bronchus V_1 , which, as pointed out already, is overdeveloped. About 2 mm. beyond the origin of artery V_1 , it gives off a large "recurrent" artery which immediately divides to accompany two of the three main branches of bronchus P. It thus supplies the dorsal two-thirds of the territory of P bronchus. The main stem of the cephalic artery then divides to give off one branch to bronchus d_1 , and one to accompany bronchus D_2 , and then bifurcates along with the lobar stem bronchus.

The Caudal Artery - It originates from the pulmonary artery, as in dog, and supplies the ventral third of territory of P-bronchus, i.e., the part not supplied by the recurrent artery.

Thus, the territory of P-bronchus is supplied by two arteries, the caudal and the recurrent.

The Left Apical Lobe

The left apical lobe is supplied by two arteries.

The Right Cardiac Lobe

The right cardiac lobe is supplied by two independent arteries.

The principal lobar artery originates slightly caudal to the caudal artery of the apical lobe and supplies the whole lobe except territory P_1 .

The second artery, designated artery P_1 , originates 7 mm. caudal to the principal artery, and supplies the area of distribution of bronchus P_1 , which has been pointed out to be overdeveloped.

The course of the lobar artery is identical to that in dog. Each of the serial bronchi receives one principal artery.

The Intermediate Lobe

The artery to intermediate lobe originates about 3 mm. distal to the origin of artery P_1 . Its extra-pulmonary course is identical to that in dog. On entry into the lobe it divides into two branches, one for each of the two main branches of the lobar bronchus, described already.

The Right Diaphragmatic Lobe

The continuation of right pulmonary artery, beyond the origin of the artery of the intermediate lobe, supplies the whole of the lobe, except territory D_1 , the artery of which, as already mentioned, originates from the dorsal aspect of the pulmonary artery opposite the interval between the two arteries of the cardiac lobe. The course of the lobar artery is identical to that in dog. Each bronchus receives one principal artery.

The Left Apical Lobe

The left apical lobe is supplied by two arteries, the

principal lobar artery and an independent artery for territory D_1 .

The lobar artery, the first branch to arise from the pulmonary artery, runs laterally to pass through inter-bronchial space D_1 - D_2 to gain the lateral aspect of the lobar stem bronchus, thereafter to accompany it up to its termination. The only branch, given off before passing through the space, is a minute twig to accompany one of the small branches of bronchus D_1 . All other branches arise from it after it has passed through the space and are distributed along the lateral aspects of their respective bronchi.

Artery D_1 , originating from the pulmonary artery 6 mm. beyond the main lobar artery, is distributed with the rami of bronchus D_1 along their medial and caudal aspects.

The Left Cardiac Lobe

The left cardiac lobe is supplied by a single artery which originates from the ventral aspect of the pulmonary artery, about 6 mm. from artery D_1 of left apical lobe. It runs along the lateral aspect of the lobar stem bronchus, but passes through interbronchial space P_2 - P_3 , thereafter to run along the caudal aspect of the lobar stem bronchus. It gives off three branches of about equal size to accompany separate rami of bronchus A_1 . Other bronchi receive one principal artery each. An additional small artery supplies the area of bronchus P_2 .

The Left Diaphragmatic Lobe

This lobe is supplied by the continuation of the left

pulmonary artery, which has a course identical to the corresponding artery on the right side. Each of the serial bronchi receives a principal artery. Territory D₁ is supplied by two additional small twigs arising distal to the origin of the principal artery.

Territory V₂ receives an additional rudimentary artery. Territory D₃ receives two arteries of about equal size.

The details of the number of arteries supplying each of the territories of the lobes are given in Table 60. Territories, omitted in the Table, were supplied by one artery each. Since no serial arrangement of bronchi has been recognised in the intermediate lobe, this lobe has been omitted.

Table 60

DETAILS OF THE NUMBER OF ARTERIES
SUPPLYING THE BRONCHIAL TERRITORIES*

Lobe	Territories supplied by two arteries	Territories supplied by three arteries
Right Apical	The caudal artery and the recurrent artery P	-
Right Cardiac	One principal and one small artery A ₁	-
	Both of about equal size p ₂ & p ₃	-
Right Diaphrag- matic	One principal and one small artery D ₂	-

contd.

Table 60 contd.

Lobe	Territories supplied by two arteries	Territories supplied by three arteries
Left Apical	One principal and one small artery D ₁ §, D ₂ , V ₂	-
Left Cardiac	One principal and one small artery P ₂	Three arteries of equal size A ₁
Left Diaphragmatic	One principal and one small artery V ₂	One principal and two small arteries D ₁
	Two arteries of equal size D ₃	

* Observations have been restricted to those territories which correspond to bronchopulmonary segments of dog. (principal artery);

§ One from lobar artery // one from artery P₃ (small artery).

§ The small artery branch of the lobar artery; the large artery, artery D₁, independent branch of pulmonary artery.

The Pulmonary Veins

Main Pulmonary Veins

Each lobe is drained by a single vein except the intermediate lobe which is drained by an additional small vein.

The veins from the apical and the cardiac lobes join to form the right and the left "cephalic" pulmonary veins. The two veins, one from each of the two diaphragmatic lobes, open into the caudal part of the left atrium, but so close to each other that they appear to open by a short common stem.

Another vein enters the left atrium directly. This vein

drains the dorso-caudal part of the P territory of right apical lobe. It runs in a medial, caudal and ventral direction, across the dorsal aspect of the stem bronchus of right lung, to enter the atrium close to the entrance of the vein of right diaphragmatic lobe. It may be noticed that this vein is identical to the aberrant vein described in the right apical lobe of cat, with the difference that in cat it drained into the vein of the right diaphragmatic lobe.

The Right Apical Lobe

The right apical lobe is drained by three veins, a "cephalic" and a "caudal", as in dog, and the aberrant vein described in the preceding paragraph.

The cephalic vein is "split" so that it is represented by two trunks, a "dorsal" and a "ventral".

The dorsal trunk runs in the space between bronchus D_2 and the dorsal of the two branches which are the result of bifurcation of the lobar stem bronchus. The ventral trunk runs in the space between the overdeveloped bronchus V_1 and the ventral of the two branches.

The two trunks drain the adjoining parts of the territories between which they lie, the dorsal trunk draining the dorsal, and the ventral, the ventral part of the lobe. They join to form a short common stem - the cephalic vein.

The caudal vein is formed by the union of tributaries $P-D_1$, $P-V_1$ and the lateral vein, identical to those of dog. The lateral vein is "split" into two veins, one joining vein $P-D_1$ and the other vein $P-V_1$. The medial vein is absent.

The caudal and the cephalic veins join, ventral to the external margin of the right pulmonary artery, to form the

lobar vein, which after a course of 13 mm. joins the vein of the cardiac lobe to form the right cephalic pulmonary vein.

The Right Cardiac Lobe

The vein of this lobe has a course identical to that of the corresponding vein of dog. Its tributaries are:-

- (1) Vein P_1-p_2 . - Territory P_1 , as pointed out already, is overdeveloped. This vein, running in interbronchial space P_1-p_2 , is a large vein, draining the whole of territory P_1 and the adjoining part of territory p_2 .

The vein crosses caudal to the lobar artery and bronchus to open into the lobar vein.

- (2) Vein p_2-P_3 (corresponding to vein P_2-T of dog). - It is a rudimentary vein which passed between bronchi m_1 and m_2 to join the lobar vein.

- (3) Vein A_1 . - It drains the dorsal part of territory A_1 .

Running under the cardiac surface of the lobe, it passes medially, and crosses the lobar artery and bronchus on their medial aspect to open independently into the lobar vein.

- (4) Vein $A_1-a_2-A_3$. - Bronchus a_2 being rudimentary, the vein commences in the space between the terminal parts of bronchi A_1 and A_3 . It then runs between bronchi A_1 and a_2 to open independently into the lobar vein.

No vein is present between bronchi a_2 and A_3 .

The Right Diaphragmatic Lobe

The lobar vein commences near the caudal end of the lobe and pursues a course identical to that in dog.

Its tributaries are:- veins D_1-D_2 , D_2-D_3 (corresponding to vein D_2-T of dog), V_1-V_2 and V_2-V_3 (corresponding to

vein V_2 -T of dog). Vein V_1 is represented by two veins, each opening into vein V_1 - V_2 .

The lobar vein receives two veins from the intermediate lobe before entering the left atrium.

The Intermediate Lobe

This lobe is drained by two veins.

The principal vein is formed by the union of two veins - one draining the dorsal part and the other the ventro-medial part of the lobe - both uniting near the hilum.

The other vein is a small vein which drains an area under the cephalic part of the right surface of the lobe near the hilum.

Both veins open separately into the vein of right diaphragmatic lobe.

The Left Apical Lobe

The lobar vein commences near the apex of lung. It runs a course identical to that in dog. The following tributaries are recognisable:-

(1) Vein D_1 - D_2 . - It receives three large tributaries from the lateral aspect of territory D_1 and runs ventrally, crossing lateral to the lobar bronchus, and then ventral to it in a medial direction to enter the lobar vein.

It also receives small tributaries from space D_1 - P_1 .

(Vein D_1 - P_1 is absent).

It also receives a vein draining the space between bronchus A_1 of cardiac lobe and bronchus V_1 of apical lobe. The presence of this vein is associated with the minor fissure being rudimentary. This vein may be designated as vein A_1 - V_1 .

- (2) Vein D_2-D_3 . - It receives a large tributary from territory D_2 , and then crosses medial to the lobar stem bronchus to enter the lobar vein.
- (3) Vein V_1-V_2 . - It drains the corresponding space.
- (4) Vein $V_2-v_3-V_4$. - This vein commences in the space between bronchi V_2 and V_4 , v_3 being rudimentary. It then passes opposite space V_2-v_3 , in a plane medial to the bronchi, to enter the lobar vein.

The space between bronchus D_3 and the remaining lobe is drained by multiple veins which form the commencement of the lobar vein. Therefore, no vein corresponding to vein D_3-T of dog is recognisable.

The Left Cardiac Lobe

The lobar vein has a course identical to that in dog. Its tributaries are:- veins A_1-a_2 (corresponding to vein A_1-T of dog), P_1-P_2 , P_2-P_3 and P_3-P_4 (corresponding to vein P_3-T of dog). The latter two veins differ from the corresponding veins of dog in crossing lateral to the lobar artery and the lobar stem bronchus before joining the lobar vein.

The Left Diaphragmatic Lobe

The commencement and course of the lobar vein is identical to the corresponding vein on the right side. Its tributaries are:- veins D_1 , D_1-D_2 , D_2-D_3 , D_3-D_4 (corresponding to vein D_3-T of dog), V_1-V_2 and V_2-V_3 (corresponding to vein V_2-T of dog).

Vein D_1 drains the medial part of territory D_1 and enters vein D_1-D_2 .

Vein D_2-D_3 is rudimentary and drains only the proximal

part of the corresponding space, the distal part being drained by multiple small branches which are tributaries of vein D_3 - D_4 .

S U M M A R Y

1. The lungs of dog consist of seven lobes, four on the right and three on the left side.

With the exception of the left apical and the left cardiac lobes, which are partially fused, all other lobes are independent, being separated by complete fissures, and possess independent hilus.

The only instance of a partial obliteration of a main fissure was a single specimen out of 60 pairs of lungs examined, in which a band of lung tissue traversed the middle of the left fissure.

2. Each lung of dog has a stem bronchus.

SECTION V

S U M M A R Y A N D D I S C U S S I O N

Beyond the hilus of the right apical lobe, and the common bronchus of the left apical and left cardiac lobes, each stem bronchus possesses a series of dorsal and a series of ventral branches.

3. Each of the seven lobes of dog is served by a single bronchus which has been called the lobar stem bronchus.

Each lobar stem gives off two main series of branches and smaller irregular accessory branches, and terminates at the terminal end of the respective lobe.

At variable points between the hilus and the terminal end of a lobe, the lobar stem bronchus may bifurcate. In the majority of lobes the bifurcation takes place at or near the terminal end of the lobe.

Apart from a difference in the direction of the branches of the lobar stem bronchi, the arrangement in each lobe is fundamentally the same as that of the branches of the main stem bronchus of each lung.

S U M M A R Y

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With the exception of the left apical and the left cardiac lobes, which are partially fused, all other lobes are independent, being separated by complete fissures, and possess independent hila.

The only instance of a partial obliteration of a main fissure was a single specimen out of 60 pairs of lungs examined, in which a band of lung tissue traversed the middle of the left fissure.

2. Each lung of dog possesses a stem bronchus.

Beyond the origin of the bronchus of the right apical lobe, and the common bronchus of the left apical and left cardiac lobes, each stem bronchus possesses a series of dorsal and a series of ventral branches.

3. Each of the seven lobes of dog is served by a single bronchus which has been called the lobar stem bronchus.

Each lobar stem gives off two main series of branches and smaller irregular accessory branches, and terminates at the terminal end of the respective lobe.

At variable points between the hilum and the terminal end of a lobe, the lobar stem bronchus may bifurcate. In the majority of lobes the bifurcation takes place at or near the terminal end of the lobe.

Apart from a difference in the direction of the branches of the lobar stem bronchi, the arrangement in each lobe is fundamentally the same as that of the branches of the main stem bronchus of each lung.

7. According to their size, the branches of the two main series in each lobe have been classified into three categories:

- (a) Normal-sized.
- (b) Overdeveloped.
- (c) Underdeveloped or rudimentary.

The sequence of the origins of the branches of the lobar stem bronchi is so variable that no two lungs are alike. However, some of the proximal branches are relatively more constant in their position.

4. The following criteria have been determined for a broncho-pulmonary segment in dog:-

- (a) That it should be a part of a lobe.
- (b) That its bronchus should have a constant or relatively constant position on the lobar stem bronchus.
- (c) That it should either constantly or with a relative constancy be served by a principal bronchus.

5. The right lung of dog has been divided into 19 and the left into 17 broncho-pulmonary segments.

The maximum variations in the size of segments are exhibited by the left apical lobe and the least by the two diaphragmatic lobes.

8. The shapes of the broncho-pulmonary segments are variable and depend upon their location in the lung.

6. Rudimentary fissures in dog are most frequent in the right apical lobe, and most infrequent in the two cardiac lobes.

All rudimentary fissures do not indicate intersegmental planes.

The relatively constant rudimentary fissures are all related to those segments which are supplied by the first branch of the lobar stem bronchus in each lobe.

7. The right pulmonary artery of dog passes caudal to the bronchus of the right apical lobe (the eparterial bronchus), and the left pulmonary artery arches over the cephalic aspect of the common bronchus of the left apical and cardiac lobes. The general relationship of each pulmonary artery to the stem bronchus is identical in each lung.

Each lobe is supplied by one principal artery except that there are additional arteries for the two apical lobes.

The arterial pattern in each lobe is almost an exact replica of the bronchial tree. The arteries accompany the bronchi very closely.

A principal artery supplies a broncho-pulmonary segment. Frequently additional minute arteries assist.

(1) When more than one artery supplies a certain area, a lobe or a segment, each artery is distributed along separate bronchial rami.

The arteries are usually related to the peripheral aspects of the bronchi with a few exceptions.

(2) No examples were found of the arteries crossing the intersegmental planes.

8. Each lobe of dog is drained by a single vein, the only exception being two intermediate lobes drained by two veins.

The vein of the intermediate lobe constantly drains into the vein of the right diaphragmatic lobe.

The resulting six main veins, three from each lung, open into the left atrium by a number of openings varying from four to six.

The venous pattern in each lobe shows a rough resemblance to the arterial and bronchial pattern, firstly in possessing

a central axial vein which runs parallel to the lobar stem bronchus, and secondly in receiving two main series of tributaries.

The tributaries of the lobar veins lie in a plane internal to the plane of the bronchial tree, opposite the inter-bronchial spaces of the two main series of bronchi, and drain the territories between which they lie.

The veins are subject to considerable variations due to their ability to "fuse", to "split" into two or more veins, and in their ability to "expand" their areas of drainage by encroaching upon distant territories.

9. For any two bronchi to be absolutely homologous, two conditions must be fulfilled:-

- (i) That their areas of distribution must be morphologically similar.
- (ii) That they should belong to the same generation.

Accordingly two types of homologies have been shown to exist:-

- (a) Absolute homology - when both conditions are fulfilled.
- (b) Partial homology - when only one of the two conditions is fulfilled. It exists in two forms:-

- (1) When two bronchi and their territories are morphologically similar but belong to different generations.
- (2) When two bronchi and their territories are morphologically dissimilar but belong to the same generation.

The main conclusion is that absolute homology between the lungs of man and dog exists only up to the lobar level when the right diaphragmatic and intermediate lobes of dog be considered as one lobar unit. The only instance of absolute homology at segmental level is between segment D_1 of left

diaphragmatic lobe of dog and the apical segment of the left lower lobe of human lung.

10. In view of an entirely different mode of their development, no absolute homology can be said to exist between the pulmonary blood vessels.
11. The presence of what has been called a lobar stem bronchus is recognised in literature only in the lower lobes of the human lung as the continuation of Aesby's stem bronchus.
Evidence has been presented which suggests that the right upper lobe of the human lung also possesses a lobar stem bronchus, with two main series of bronchi, identical to that of right apical lobe of dog. The lobar bronchus of the right upper lobe of human lung has been considered to be continued into the anterior segmental bronchus.
According to this concept the apical and the posterior segmental bronchi are looked upon as side branches of the lobar stem bronchus.
12. It has also been shown that this concept is consistent with the detailed accounts of the bronchi of the right upper lobe given by Ewart (1889), Appleton (1945), and Boyden and Scannell (1948).
13. The course and relations of the right and left pulmonary arteries in dog are similar to those in man.
14. The arterial supply of the right apical lobe of dog resembles the arterial supply of the upper lobe of human lung, firstly in the presence of arteries corresponding to the anterior and posterior ascending arteries of the human lobe, and secondly in the presence of the recurrent arteries.
15. The right cardiac lobe in dog is constantly supplied by

20. a single artery, whereas in man the artery of the middle as lobe is generally represented by two arteries. the guinea
15. Both diaphragmatic lobes of dog and both lower lobes of
21. man are supplied by the continuation of the main pulmonary arteries. the guinea baboon, resemble the bronchial tree of
16. dog. In man the left upper lobe receives arteries from the ventral, the cephalic, and the dorsal (interlobar) parts the of the arch of the left pulmonary artery. In dog the lung arteries to the corresponding lobes, i.e., the left apical and the left cardiac, arise only from the dorsal part of the pulmonary artery. the caudal end of the lobe.
17. (c) In man two pulmonary veins drain a large majority of the right and the left lungs. In dog three veins are more frequent on the right side, but on the left side, two veins and three veins are found with an equal frequency. relation
18. Both in man and in dog, the left lung shows tendency to possess a lesser number of pulmonary veins. of lesser size
19. The lungs of the cat, the civet, the rhesus monkey and the guinea baboon, consist of 7 lobes, as in dog. The following differences exist in their external morphology:-
- (a) In the cat and in the civet the right apical lobes are more elongated as compared to the right apical lobe of dog.
- (b) In the guinea baboon, the sagittal fissure is partially obliterated. terminates at the caudal and the ventral end
- (c) The intermediate lobe of the cat has a "contracted" and rounded ventral end. disappears resemble the human lungs in
22. (d) In the region of the apical lobes the lungs of the rhesus
23. monkey appear broader from side to side than the lungs of dog. bronchial tree of man, so that its main subdivisions correspond

20. The apices of the lungs of civet and cat are pointed as in dog. The apices of the rhesus monkey and the guinea baboon are rounded.
21. The bronchial trees of the cat, the civet, the rhesus monkey and the guinea baboon, resemble the bronchial tree of dog. The following differences exist:-
- (a) The lobar stem bronchus of the right apical lobe of the cat's lung terminates at the ventral border of the lung between the apex of the lung and ventral end of the lobe.
 - (b) The lobar stem bronchus of the intermediate lobe of cat terminates at the caudal end of the lobe.
 - (c) The lobar stem bronchus of the right apical lobe of civet terminates at the apex of the lung.
 - (d) The lobar stem bronchus of the right apical lobe of rhesus monkey terminates very early by a bifurcation so that no serial arrangement is present.
 - (e) The serial arrangement of the branches of lobar stem bronchus of right apical lobe of guinea baboon is not well marked.
 - (f) A serial arrangement of bronchi is not well marked in the right cardiac lobe and the intermediate lobe of the guinea baboon. In the intermediate lobe the lobar bronchus bifurcates into two equal-sized branches and each branch terminates at the caudal and the ventral end respectively.
22. The lungs of the chimpanzee resemble the human lungs in the number of lobes and in their external morphology.
23. The bronchial tree of the chimpanzee resembles the bronchial tree of man, so that its main subdivisions correspond

to the universally recognised pattern of the human lung.

A lobar stem bronchus is present in the right upper

and in the right middle lobe.

The arrangement of the bronchi of the right middle lobe resembles that of the right middle lobe of the human lung on the one hand, and that of dog's right cardiac lobe on the other.

The bronchial pattern of the left upper lobe-upper division resembles the bronchial pattern of the right upper lobe of human lung. The anterior segmental bronchus appears to be the continuation of the upper division bronchus.

24. Bronchus P_1 of the right cardiac lobe is overdeveloped in the guinea baboon and the chimpanzee.

Bronchus P_1 of both cardiac lobes is overdeveloped in the rhesus monkey.

25. The main pulmonary arteries of cat, civet and guinea baboon resemble in their course the corresponding arteries of dog.

The right apical lobe of each of these three animals is supplied, as in dog, by a cephalic and a caudal artery. The right apical lobe of the civet and the cat is supplied by a third additional artery - artery V_{1+2} in civet, and artery V_1 in cat.

The right cardiac lobes of the guinea baboon and the civet are supplied by two arteries, the additional artery being an independent artery to territory P_1 .

In the cat, the civet and the baboon, the left apical lobe is supplied by a principal lobar artery. One additional artery (to territory D_1) supplies this lobe in guinea baboon,

and two additional arteries (both to territory D_1) supply this lobe in the civet and the cat.

26. In the cat, the civet and the guinea baboon, the general arrangement of lobar veins resembles those of dog, so that no characteristic feature is noticed except that:-

(a) The intermediate lobe of guinea baboon is drained by two veins.

(b) An aberrant vein drains the right apical lobe of the cat and of the guinea baboon.

The apical lobe of each of these three animals is drained by a cephalic and a caudal vein as in dog.

27. A simple technique for preparing celloidin bronchial casts from lungs hardened in situ, and of preparing triple celloidin casts by using fresh lungs, has been described and used.

28. A system of nomenclature for bronchi and pulmonary blood vessels has been suggested and used for dog. The same nomenclature has been used for other animals.

ing to these statements of Gilmour, and the fact that no two bronchograms were identical, make the introduction of an element of arbitrariness in the selection of bronchi, which may be designated as segments, inevitable.

The accepted pattern of the bronchopulmonary segments of man, and the pattern of segments determined in this study for dog, are not based on identical arbitrary criteria, because, due to different bronchial patterns of these two animals, it is not possible to do so.

The complexity of the problem

DISCUSSION

Most of the relevant points have been discussed in the text of the thesis. A few others, which have not been touched upon and those which have been deferred for convenience may be dealt with now.

The study shows that the pattern of bronchopulmonary segments depends upon the bronchial pattern in a lung.

Jackson and Huber (1943), writing about the human lung, have remarked that a bronchopulmonary segment is "the area of distribution of any bronchus".

The bronchial arrangements in the lungs of dog and other animals studied rightly remind one of the drawings of Willis and Huntington (Figs. 30 and 31) as observed by Neil and Gilmour (1946), who stated that "every orifice seen in a lobar bronchus supplies a segment or at times a segmentellette".

The complicated segmental picture that would ensue, according to these statements of Jackson and Huber, and Neil and Gilmour, and the fact that no two bronchial trees are identical, make the introduction of an element of arbitrariness, in the selection of bronchi, which may be designated as segmental, inevitable.

The accepted pattern of the bronchopulmonary segments of man, and the pattern of segments determined in this study for dog, are not based on identical arbitrary criteria, because, due to different bronchial patterns of these two mammals, it is not possible to do so.

The complexity of the problem of homologization of two

bronchial territories is obvious, and is further increased by a lack of agreement on the true mode of division of bronchi. However, a comparison of the bronchial territories of the lungs of man and of dog, on the basis of the principles of homology discussed already, shows that absolute homology is limited up to the lobar level. Traced further, the homology becomes partial at segmental level, and then vanishes entirely. the 2nd, the left upper lobe-upper division bronchus belongs to the 3rd generation. The homology between them,

As pointed out in the text, it remains to examine how far the commonly believed homologies between the bronchial territories of the right and the left sides are tenable, bearing the principles of homologies presented in this study.

Ewart (1889) was the first to point out that the left upper lobe bronchus "corresponds strictly neither to the right upper lobar, nor, as Aebj contends, to the right middle lobar bronchus, but to both combined". Since then this has been the generally accepted view and has been reiterated by most of the recent authors, obviously on the basis of their similarity of external form and the internal structure. The occurrence of instances in which lingula is separated from the upper lobe by a deep fissure is responsible to some extent for fortifying this opinion. Churchill and Belsey (1939), and Huizinga and Smelt (1949) have pointed out that the embryologists are not agreed upon this homology.

The segments of the right and the left lungs are usually considered to correspond on the basis of their external morphological and topographical resemblance. The adoption of a common terminology for the segments of both lungs further

strengthens this impression.

The above views may now be reviewed in the light of the criteria for absolute homology mentioned in the text.

The various generations exhibited by the bronchi of the right and the left human lungs, derived from Tables 39 and 40, are compared in Table 61.

It will be noticed that whereas the right upper lobe bronchus belongs to the 2nd, the left upper lobe-upper division bronchus belongs to the 3rd generation. The homology between them, therefore, is only partial. The right middle lobe bronchus and the lingula bronchus, however, belong to the same generation, and, therefore, prove to be absolutely homologous. Thus the commonly held view that the left upper lobe corresponds to the combined right upper and middle lobes, cannot be taken to imply the existence of absolute homology between them.

The two lower lobes, in the same Table, can be seen to belong to different generations, and are, therefore, not absolutely homologous.

It can also be seen that the corresponding segmental bronchi may or may not belong to similar generations and, therefore, the homology between them may or may not be absolute.

A comparison of the generations of segmental bronchi of the right and the left lungs of dog, analysed in Table 62, offers similar conclusions. In this Table comparison has been restricted to the generations of bronchi of the territories which are common to both lungs.

Thus, for morphological resemblance to exist between two territories on the opposite sides, it has been found that it is not necessary for the supplying bronchus to belong to the

Table 61

COMPARISON OF THE GENERATIONS OF BRONCHI OF THE
CORRESPONDING TERRITORIES OF THE RIGHT AND
THE LEFT HUMAN LUNGS

<u>Territory</u>	<u>Generations</u>	
	<u>Right Lung</u>	<u>Left Lung</u>
<u>Right Upper Lobe;</u> <u>Left Upper Lobe-</u> <u>Upper Division</u>	2	3
Posterior segment	3; 3 or 4; 4	5 or 6
Apical segment	3; 3 or 4; 4	5; 6
Anterior segment	3; 4	4
<u>Right Middle Lobe;</u> <u>Left Upper Lobe-</u> <u>Lower Division</u>	3	3
At segmental level comparison cannot be made on account of different patterns on the two sides.		
<u>Lower Lobe</u>	3	2
Apical segment	4	3
Anterior basal segment	6; 7; 8	4; 5; 6; 7
Lateral basal segment	7; 8; 9	5; 6; 7
Posterior basal segment	6; 7; 8; 9	4; 5; 6; 7
Medial basal segment	5	-

Table 62

COMPARISON OF THE GENERATIONS OF BRONCHI
OF THE CORRESPONDING TERRITORIES OF THE
RIGHT AND THE LEFT LUNGS OF DOG

<u>Territory</u>	<u>Generations</u>	
	<u>Right Lung</u>	<u>Left Lung</u>
<u>Apical Lobe</u>	2	3
Segment D ₁	4; 4 or 5	4
" D ₂	6; 6 or 7; 7; 8; 12 or 13	5; 5 or 6; 6; 6 or 7; 7
" V ₁	4 or 5; 5	5; 5 or 6; 6
" V ₂	6; 6 or 7; 7; 8; 8 or 9	6; 6 or 7; 7; 7 or 8; 8; 8 or 9; 9; 13.
<u>Cardiac Lobe</u>	3	3
Segment P ₁	4; 5	4
" P ₂	5; 5 or 6; 6; 7	5 or 6; 6; 6 or 7; 8
" A ₁	5; 5 or 6; 6	5; 5 or 6
<u>Diaphragmatic Lobe</u>	4	2
Segment D ₁	4; 4 or 5; 5; 5 or 6	3
" D ₂	7; 8; 8 or 9	5; 6
" V ₁	5 or 6; 6; 7	4
" V ₂	7 or 8; 8; 8 or 9 or 10; 9; 10; 10 or 11	5; 6; 6 or 7; 7.

The differences in the branching of the bronchi in the right and left lungs of dogs have already been referred to in the text.

It has been observed that in dog and in a few other animals studied, one of the chief features in the structure of a lobar stem bronchus from which bronchus arises in a manner which suggests a monopodial branching.

same generation. The influence of space on the growth of bronchi has been stressed by Flint (1906), Huntington (1920), and subsequently by many other authors. It is, therefore, obvious that the existence of a morphological resemblance in the two territories of the opposite sides is the result of two branches belonging either to similar or different generations growing into identical spaces. accord with the statement of Smyth quoted above. The same explains a reduction in the

Regarding the significance of the different segmental patterns of the human and dog's lungs, a possible explanation may be sought in the different shapes of the thoraces and in the apparently different modes of branching. human lung,

Smyth (1949) has remarked, "..... it would appear that the early branching of the human and the mammalian bronchial tree is monopodial, but due to the differences associated with the orthograde position, the shape of the human lungs is more truncated - tending more towards the spheroidal - than that of other mammals; the branching of the human bronchial tree, therefore, becomes dichotomous much sooner than in other mammals - during the first three or four generations of branching; in fact, when the typical mammalian pattern is still monopodial". are laterally expanded and are flattened

The differences between the shapes of thoraces and the resulting effects on the morphology of lungs have already been referred to in the text. ches, which supply the central

part It has been observed that in dog and in a few other animals studied, one of the chief features is the existence of a lobar stem bronchus from which branches arise in a manner which suggests a monopodial branching. But it has also been

observed that the termination of the lobar stem bronchus occurs not infrequently by bifurcation, but this happens usually after a large number of branches have been given off monopodially. In the human lung, on the other hand, bifurcation appears very much earlier so that the individuality of the lobar stem bronchi is lost at a much earlier stage.

This observation is in complete accord with the statement of Smyth quoted above. The same explains a reduction in the number of segments into which the human lung is divisible.

Here it is interesting to note that Neil et al (1938), referring to the absence of the homologue of the subapical bronchus in one or two of their cases, in the human lung, state: "The significance of this in the human is not clear at present. It may be that it is a recessive variation". The earlier appearance of "dichotomy" in the human lung, discussed above, is a plausible explanation of the significance of this variation.

In addition to the reduction in the number of segments in the human lungs, there are other differences due to their different dimensions.

The human lungs are laterally expanded and are flattened from before backwards. One of their characteristics, as a result of this, is the appearance of well-marked lateral branches, the "axillary" branches, which supply the central parts of the costal surfaces of the two lungs, composing the axillary areas, described by Brock.

The individual segments, too, show characteristics due to this expansion.

Reference has already been made (vide page 272) to the overdevelopment of the posterior and the apical segments in the right upper lobe of human lung. While each one of them approaches a co-equality of size with the remaining lobe, i.e., the anterior segment, the corresponding segments, P and D₁ of the right apical lobe of dog, are much smaller, relative to the remaining portion of the lobe.

In the right human middle lobe, the lateral segment, corresponding to segment P₁ of the cardiac lobe of dog, is so much overdeveloped that it becomes equal in size to the remaining lobe, i.e., the medial segment, which it overlaps. This equality in size results in an equal division of the lobar bronchus, giving an appearance of dichotomy.

Here, it is interesting to note that territory P₁ has been found to be overdeveloped in the other three primates included in this study (see Summary, item 24, page 393).

In the chimpanzee it is so much overdeveloped that it forms the lateral one-third of the whole lobe so that it resembles the lateral segment of the human lung. The remaining lobe, corresponding to the medial segment in the human lung, retains the serial arrangement of branches observed in the three carnivores included in this study. Although, in view of the limited nature of the material, it may not be taken to represent an evolutionary trend, yet it presents an interesting observation, because it does suggest a stage of transformation of a monopodial appearance into a dichotomous one.

The only segment in the left upper lobe of human lung, which shows a morphological resemblance to a segment in dog, is the posterior segment which corresponds to segment D₁ of

left apical lobe of dog. It shows no special characteristics, except that it has undergone a lateral expansion as a part of the general expansion of the lungs.

In both lower lobes of the human lungs, the apical segment is very much expanded in the lateral, dorsal and vertical directions, as compared to segments D_1 of the diaphragmatic lobes in dog. It extends up to the mid-axilla (Foster-Carter and Hoyle, 1945). This, perhaps, is another factor responsible for the vestigial character of the subapical branches in the human lower lobes.

Due to the disappearance in the human thorax of the recess of the pleural sac, which is present in dog, and lodges the intermediate lobe, one would anticipate almost a complete absence of the medial basal segment in the right lung. But its presence as a segment of considerable size can be explained to be due to the provision of space for it by the lateral expansion of the chest.

The remaining basal segments are characterised, as compared to the corresponding areas in dog, by a laterally expanded appearance. The anterior basal segment appears to have been "compressed" from the fissural aspect due to the greater obliquity of the oblique fissures, which is also associated with the vertical expansion of the apical segment, referred to above. The other segments show no other special characteristics.

Fig. 2, these apicals correspond to bronchi D_1 and D_2 . In

Another point, which has been deferred for discussion, is to review the homologies at segmental level determined by Neil and co-workers in their various articles. Appleton (1949) has already pointed out the inadequacy of the data on

which they based their conclusions in respect of the homologies of the various bronchi. Their main findings are discussed below:-

Referring to the bronchi of the right upper lobe (the apical lobe) of various mammals studied by them, Neil and Gilmour (1949b) state that, "the upper lobe stem divides into two trunks - the subapical below and an upper one". This division they found to exist in all the mammals they examined. This observation is in agreement with the findings of the present writer, as far as all the lungs of dog and other mammals studied (except those of the chimpanzee and man) are concerned, their "subapical" being identical to the P-bronchus of the present study.

In the lungs of the chimpanzee, it was found that the first division of the right upper lobe bronchus results in a common stem of the subapical and apical bronchi. In one of the five casts of the human bronchial tree, it was found that the arrangement was similar to that in the chimpanzee. In the other four the mode of division was what is usually described as the trifurcate pattern, so that the subapical bronchus cannot be said to be the first branch in any of the five casts.

Further, they stated: "In the dog two well-marked apicals come off from this trunk (upper)" In their Fig. 2, these apicals correspond to bronchi D_1 and D_2 . In the present study it has been shown that if at all any bronchi deserve to be called apical bronchi, they are D_3 and D_4 .

In dog they also recognised the existence of a "well-marked axillary branch" arising from the upper trunk, of the

right upper (apical) lobe. This study confirms their finding, the "axillary" branch corresponding to bronchus V_1 , which was well-marked in all the specimens examined by the present writer.

Referring to the bronchi of the right apical lobe of monkey, illustrated in their Fig. 3, they state: "two apicals are fused into one segmental bronchus". For this presumption, as pointed out by Appleton (1949), there is no embryological evidence. In the present writer's opinion, the two "fused" apicals should simply be considered as bronchus D_1 .

Neil, Gilmour and Gwynne (1939) observed: "Distal to the apical bronchus of the lower lobe we found in all our mammalian specimens homologues of the subapical bronchus or bronchi. In the human we have observed it arising from the dorsal, mesial or lateral aspect of the right main bronchus..... On the left side we have found it situated dorsally, mesially, laterally, and twice ventrally." The only decisive criterion they have used in determining this homology is the position of the subapical in relation to the apical bronchus, i.e., bronchus D_1 of the diaphragmatic lobe, irrespective of the aspect of origin of the "sub-apical". This, in the opinion of the present writer, is an entirely inadequate criterion for determining homology. One of the chief clues to the identity of a bronchus is the aspect of its origin from the parent bronchus. This fundamental fact they have entirely ignored.

This study would not be complete without comparing the writer's findings in dog with some of the findings of the pioneer comparative morphologist — Aeby.

Aeby's common basic mammalian plan of bronchi comprises

a stem bronchus in each lung with its four dorsal and four ventral branches which, according to him, usually alternate. The findings in dog are:-

<u>Right Lung</u>	<u>Minimum</u>	<u>Maximum</u>	<u>Average</u>
Dorsal Branches	4	8	5.7
* Ventral "	5	9	6.6
<u>Left Lung</u>			
Dorsal Branches	4	8	5.7
* Ventral "	5	9	6.3

These findings, therefore, do not tally with those of Aeby.

It has also been seen that the dorsal and ventral branches do not alternate regularly in dog. The alteration of dorsal and ventral branches, in the human lung, has already been refuted by Brock.

As observed by Aeby, the branches of the two main series are never exactly opposite each other. The "spiral" arrangement of branches, described by the present writer, is in agreement with Aeby's observation. But the same is also applicable to the bronchi of lobes other than the diaphragmatic lobes, supplied by the continuation of Aeby's stem bronchi.

This study confirms Aeby's observation that the accessory bronchi vary in number and position, and that they are more abundant in the lower part of the bronchial tree. The same remarks apply equally to all the lobes, in which they are more abundant in the distal part of each lobe.

* Aeby's bronchus V₁ on the right side is the bronchus of the right cardiac lobe, and on the left it is the common bronchus of the apical and cardiac lobes. These figures have been calculated from Table 4 (page 96), which gives the minimum, maximum and average number of dorsal and ventral branches in the diaphragmatic lobes, supplied by the respective stem bronchus. To the figures given in this Table, Aeby's V₁ bronchi have been added.

Tonelli's Work on the Lungs of Dog

Tonelli published, in 1951, an article on the morphology of the lungs, the bronchial tree and the bronchopulmonary segments of dog. He based his work on dissections and Wood's metal casts of the bronchial tree. He has added a brief note on the bronchoscopic aspects and has also given a comparative note on bronchopulmonary segments of dog and man. He has not dealt with the pulmonary blood vessels.

In the following account only some of the main features of his work will be briefly reviewed.

Tonelli's description of the lungs and his account of the arrangement of lobar bronchi is in agreement with the account given in the present work. He has not recognised the existence of a structure corresponding to the lobar stem bronchus and of the serial arrangement of bronchi, except in the two diaphragmatic lobes (his inferior lobes). But there are statements which imply the occasional existence of such an arrangement in some of his specimens. In the present study, this arrangement was found to be the rule. He has not mentioned the existence of accessory branches in lobes other than the diaphragmatic lobes in which he called them 'medial bronchi'.

Without taking into consideration any definite criteria, he has divided each lobe into a fixed number of segments which corresponds to the number of branches into which he divides each lobar bronchus. No variations have been described. In the present study, on the other hand, stress has been laid on the variability of the number of branches given off by the

lobar stem bronchi. Only a few of these branches have been selected as true segmental bronchi, the remaining being grouped as a single composite segment consisting of a variable number of potentially true segments. Thus, whereas in this study every branch, irrespective of its size, has been taken into consideration, Tonelli appears to have focussed his attention on the obviously principal branches only. This has resulted in different segmental patterns arrived at by him and by the present writer.

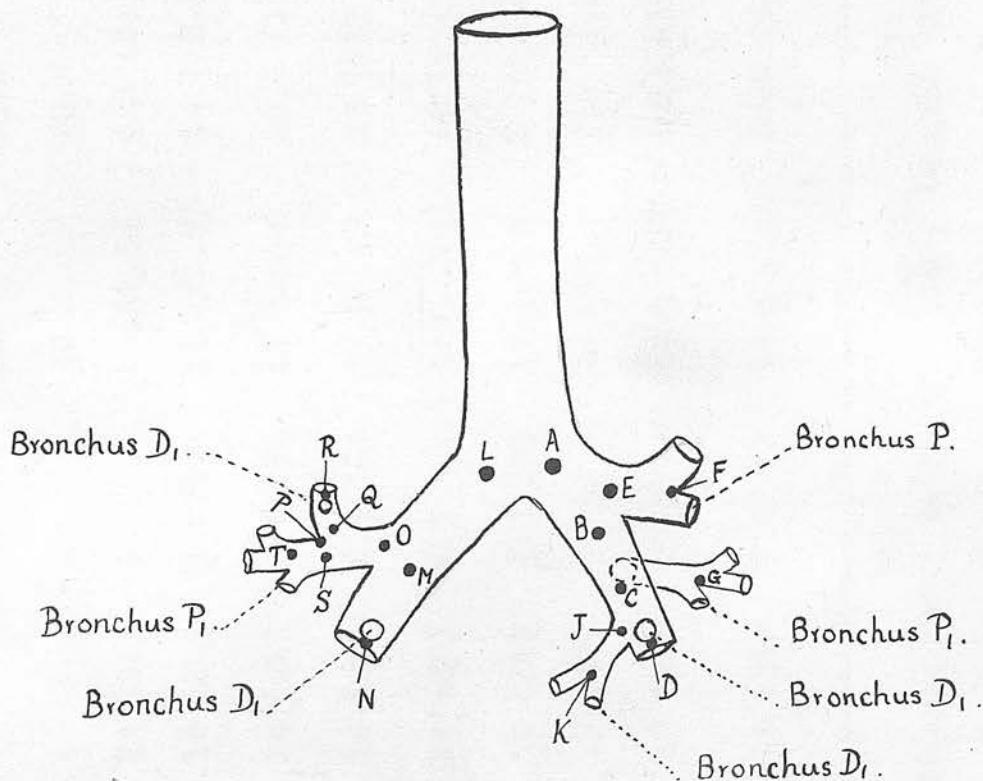
The number of segments into which each lobe has been divided by Tonelli, and the number of segments given in this study, are compared below:-

<u>Lobe</u>	<u>Tonelli</u>	<u>Present Writer</u>
Right Apical	4	6
Right Cardiac	3	5
Right Diaphragmatic	7	5
Intermediate	2	3
Left Apical	3	6
Left Cardiac	2	5
Left Diaphragmatic	6	6

The only lobe in which the segmental patterns agree is the left diaphragmatic lobe.

Measurements of the Bronchial Tree of Dog

Some measurements were made on the bronchial tree of dog in dissected specimens as well as in casts. The points used for measurement are schematically depicted in the following figure.



Scheme employed for measuring bronchi

Right main bronchus	- from A to B
Bronchus Intermedius of Ewart	- from B to C
Bronchus right apical lobe	- from E to F
" " cardiac lobe	- from C to G
" " diaphragmatic lobe	- from C to D
" Intermediate lobe	- from J to K
Left main bronchus	- from L to M
Common bronchus-left apical and cardiac lobe	- from O to P

Bronchus	No. of Specimens	Lengths		Breadths	
		Min.	Max.	Min.	Average
Right Main Bronchus	69	10	20	12	13.6
Left Main Bronchus	69	15	30	20	20.4
Bronchus - Right Apical Lobe	14 (21)	4 (5)	8 (12.5)	7	6.5 (8)
Bronchus - Right Cardiac Lobe	14 (21)	9 (9)	16 (22.5)	11	14 (17.8)
Bronchus - Right Diaphragmatic Lobe	14 (21)	9 (9.5)	15 (24)	14	10.6 (17.10)
Bronchus - Intermediate Lobe	14 (21)	8.5 (10)	17.5 (27.5)	14	12.5 (22.5)
Subsegmental branches of Left Apical and Cardiac Lobes	14 (21)	6.5 (10.5)	12.5 (20)	7	10 (17.11)
Bronchus - Left Apical Lobe	14 (21)	3.5 (10)	12 (15.5)	5	6 (10)
Bronchus - Left Cardiac Lobe	14 (21)	3 (15)	12 (20)	5	7.5 (13.5)
Bronchus - Left Diaphragmatic Lobe	14 (21)	10 (15)	20 (25)	10	14 (19)
Bronchus - Intermediate Lobe	14 (21)	7 (15.5)	20 (25)	10	13.5 (19.5)

Bronchus left apical lobe - from Q to R
 " " cardiac lobe - from S to T
 " " diaphragmatic lobe - from M to N

The measurements are recorded in the accompanying table.

Bronchus	No. of Specimens	L e n g t h s		B r e a d t h s	
		Min.	Max.	Min.	Max. Average
Right Main Bronchus	69	10	20	12	28 18.8
Left Main Bronchus	69	15	30	10	20 14.5
Bronchus - Right Apical Lobe	14 (21)	4 (5)	8 (12.5)	7	12.5 10.3
Bronchus - Right Cardiac Lobe	14 (21)	9 (9)	16 (22.5)	5	11 7.2
Bronchus - Right Diaphrag- matic Lobe	14 (21)	7 (3.5)	15 (14)	8	14 11.2
Bronchus - Intermediate Lobe	14 (21)	8.5 (6)	17.5 (22.5)	5	8.5 5.8
Common Bronchus of Left Apical and Cardiac Lobes	14 (21)	6.5 (6.5)	12.5 (13)	7	11 9
Bronchus - Left Apical Lobe	14 (21)	5.5 (4)	12 (15.5)	5	10 7.2
Bronchus - Left Cardiac Lobe	14 (21)	5 (3)	10 (10)	5	7.5 6.3
Bronchus - Left Diaphragmatic Lobe	14 (21)	10 (5)	16.5 (18)	7	14 10.4
Bronchus Intermediate (of Ewart)	14 (21)	7 (5.5)	13.5 (19)	10	23 17

* Figures in parenthesis refer to casts. Only lengths were measured on casts.

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